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New Settling Basin of the Water Works at Kansas City

By Wynkoop Kiersted*

The original settling basins of Kansas City, Mo., located at Quindaro, Kan., were described in the course of a series of articles on the water-works of that city which appeared in Engineering News, July, November and December 1887. The articles were written by the designer, the late G. W. Peason, at that time chief engineer of the National Water Works Co. In 1898 and 1899, after the city had purchased the water-works property of the National Water Works Co., the writer designed and carried out a system of reinforcement for the division walls of the settling basins and arranged the basins for operation upon the continuous flow and displacement method, by cutting long notches in the division wall through which the water passed from one division of the settling basin to another. The original settling basin, as modified, continued to serve the city for water clarification purposes until the fall of 1908 when directions were given the writer to prepare plans and specifications for an extension of the settling basin.

The city contracted with W. C. Mullins of Kansas City, Mo., for the construction of the new settling basin in November, 1908. The new basin is located immediately east of the original settling basins. It is 630 ft. long by 450 ft. wide, inside measurements, at the top of the wash wall, 24 ft. in depth at the toe of the embankment and 29 ft. in depth at the entrance of the drain pipes, and contains, in operation, from forty to forty-five million gallons of water.

The basin is of earth construction almost exclusively. A large portion of the site of the new basin had for a number of years been regularly flooded in winter time and the ice crop harvested by private parties. Although ice harvesting had been discontinued at the time of construction, still annual overflows and storms had filled the depressions with water and kept saturated the silt and gumbo peculiar to the Missouri river bottoms. Several feet of this soft and unstable material was removed from the inside of the reservoir, as well as from under the embankment site, in order to find suitable material upon which to start the embankments.

The bottom of the reservoir, inside of the embankments, was laid out in six rectangles or pockets about 195 ft. long and 179 ft. wide. Each of these rectangles was either excavated or built conforming substantially to an inverted pyramid with its apex at the center 5 ft. below the base perimeter. At the apex of each of these six inverted pyramids or drainage pockets was a drain valve communicating with a 24-in. lateral drain pipe. Each of the six 24-in. lateral drain pipes discharges into a main drain pipe, 42 in. in diameter, extending centrally from the outside toe of the south embankment to the outside of the north embankment and thence to the river. All of the drain pipes are of lead-jointed cast-iron pipes, laid on a reinforced-concrete foundation.

The westerly embankment of the new basin is built against the easterly embankment of the original basin. In building the new embankment against the old embankment, the earth of the old embankment was cut out into steps to better insure the security of the new work, as shown in Fig. 3.

In this way the 2 to 1 slope of the old embankment was flattened to a slope of 3 to 1. The slopes of the other embankments of the new basin, both inside and outside, are 2 to 1; the top width is 15 ft.

It is unnecessary to go into the details of the construction of this new basin as they embrace nothing of unusual interest, except possibly the substitution of a gumbo lining for the ordinary concrete lining of the inside slopes of the embankments and of the bottom of the reservoir. The embankments were constructed entirely of clay hauled from the adjoining bluffs, thoroughly watered and rolled in 6 to 8-in. layers, increasing the weight of earth in the embankment about 10%.

Fig. 3 is a typical section of the inner slope of the west embankment between the old and the new basin; it is also a

Fig. 1. Building the North Embankment, April 1, 1910

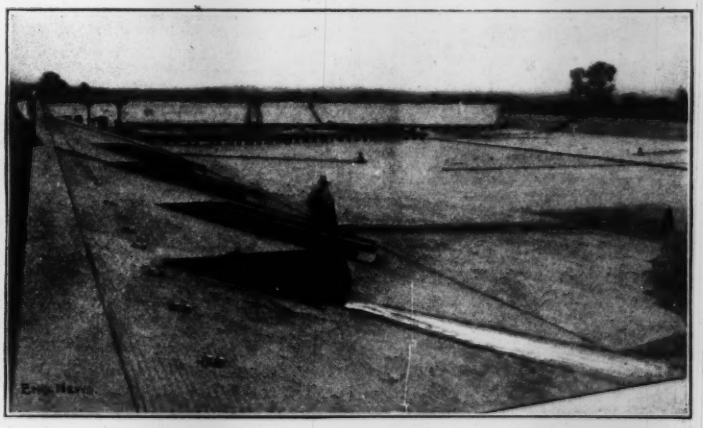

Fig. 2. Basin Ready for Use, October, 1910

Figs. 1 and 2. The New Settling Basin at Kansas City, Mo.

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typical section of the finish of the inner slope of the north, east and south embankments, except that the slope of these embankments is 2 to 1 instead of 3 to 1 to the old earth work of the original settling basin.

The 18 in. of puddle shown on this typical section illustrates the method of waterproofing the embankments. This puddle consists of the gumbo removed from the interior of the reservoir during construction, or borrowed from the adjoining bottom of the Missouri River, laid down in 6-in. horizontal layers against the earth embankment previously watered, and thoroughly compacted by rolling or hand tamping. On the 3 to 1 slope team-work in placing and compacting the gumbo lining was feasible, but on the 2 to 1 slopes the gumbo lining was largely hand-placed and tamped. It was found that but a small amount of sprinkling was needed to bring the gumbo to the desired consistency for puddling.

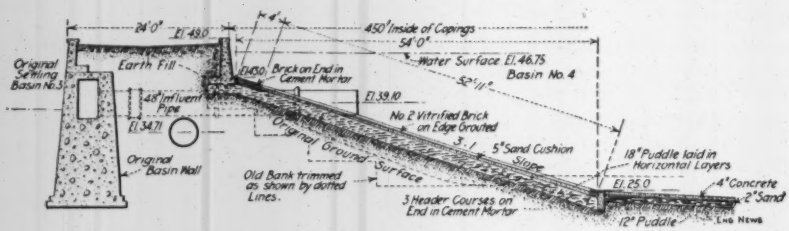

FIG. 3. SECTION THROUGH EMBANKMENT OF NEW SETTLING BASIN, KANSAS CITY, MO.

Five inches of river sand was spread over the gumbo lining. A 4-in. layer of brick paving blocks was placed dry upon the sand and grouted with Portland cement and two of sand, with the exception of header courses at the top of the slope, which are laid in one to two Portland cement mortar.

The drainage pockets in the bottom of the reservoir were formed partly by excavating the natural ground and partly by building embankments with clay taken from the neighboring bluffs, rolled down in 6-in. layers. All of the pockets are lined with gumbo taken from the river bottom, deposited in two 6-in. layers, each layer being thoroughly sprinkled and rolled. Two inches of river sand was deposited on the top of the gumbo puddle and upon the sand is placed a 4-in. layer of 1:3:6 Portland cement concrete —the concrete being used on the bottom instead of brick block, as the concrete affords less resistance to the movement of sand and silt during the process of washing.

The wash wall of reinforced concrete (Fig. 3) made in proportions of 1, 3 and 5 of cement, sand and stone, respectively, gives a top finish to the interior of the settling basin, breaks the wave action and affords a good ice exposure.

Fig. 1 shows the north bank about on a level with the bottom of the reinforced-concrete wash wall, with its gumbo lining nearing completion. Fig. 2 shows the new basin completed in October, 1910, and water entering it for the first time from the old settling basins through the 48-in. influent pipe shown in the foreground. On the left of Fig. 2 are shown three 30-in. pipes descending the slope to a point near tthe bottom of the basin. These pipes are intended for use at any time it becomes desirable to deliver water at the bottom of the new basin or to use the new basin as a river-water basin.

The writer's design contemplates the use of the new basin as a clear-water basin, as it is the only basin which is large enough to give a desirable amount of clear-water storage. As now operated, the clear water discharges into the new basin at the southwest corner and is expected to circulate entirely through the basin by a swinging movement and to be taken out of the basin near the foot of the slope of the north embankment.

The effluent pipe system (see Fig. 4) consists of a line of 36-in. pipe parallel with the north embankment, meeting in the middle of the basin in a 48x36-in. cross. At each end of the 36-in. effluent pipe is an elbow turning upward. In the middle of the basin at the point of junction of the 48-in. effluent line with the 36-in. effluent lines there is a 48-in. 45-degree bend pointing upward, with the opening into the bend throttled to 30 in. in diameter. The 48-in. effluent line is receiving the water from the three effluent intakes above described is laid southward along the berm dividing the east from the west drainage pockets, thence turns westward across the basin and passes through the west embankment and into the small horseshoe basin of the original construction. Fig. 2 gives a comprehensive view of the effluent pipe system and the 6-in. high-pressure wash-pipe system laid upon the berms in the bottom of the basin and supplied at intervals with the necessary hose nozzles. Fig. 2 also shows a hydraulic drain valve at the low point in each of the six drainage pockets. These valves are manipulated by high-pressure water supplied from the pumps in the adjoining pumping station, controlled by the usual four-way valve, located in a valve pit in the adjoining embankment.

A steel tower over the hydraulic valve in the northwest drainage pocket supports an extension valve stem, by means of which this drain valve can be opened by hand in the event of the failure of the hydraulic method of valve operation.

FIG. 4. EFFLUENT PIPE SYSTEM, NEW SETTLING BASIN, KANSAS CITY, MO.

At the point where the 48-in. effluent pipe passes through the west embankment into the suction basin a valve tee is turned upward immediately under a steel trestle, and a second valve set vertically in the main run of the 48-in. effluent pipe. The latter valve admits of cutting off the three effluent openings near the north embankment and the former

valve, when open, admits water from the new basin at a high level. Thus far no occasion has arisen to use this emergency effluent.

Fig. 5 is a bird's eye view of the set-

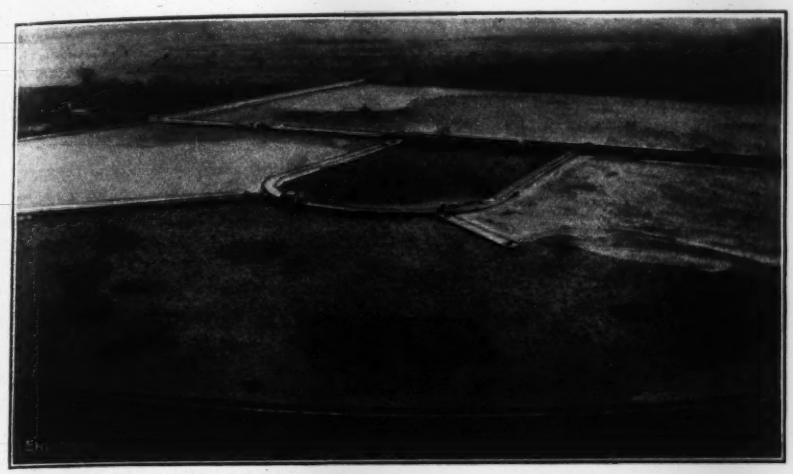

FIG. 5. BIRD'S-EYE VIEW OF NEW SETTLING BASIN IN OPERATION, KANSAS CITY, MO.

ting basins in operation, the original basins appearing in the foreground. As at present operated, the river water is received in a well, the curb of which is shown projecting above the ground in the upper left-hand corner of the view. The river water enters this well from the pumps, flows through conduits and enters the bottom of the adjoining division of the original settling basin through a series of openings, passes from this basin through a notch in the division wall into the second division of the original settling basin, shown in foreground of Fig. 5, thence into the third division of the original basin, thence through a 48-in. pipe into the southwest corner of the new basin. From the new basin, the water passes into the small horseshoe basin, which serves as a suction basin.

Recently, when turbid water reached the new settling basin, a question arose whether a desirable circulation existed in this basin and whether the three effluent intakes near the north embankment, admitting water near the bottom of the basin, were giving results as desirable as those which might result or would result from effluent intakes located at a higher elevation. In order to throw light upon these doubtful points, samples of water were taken along two transverse sections of the basin: the first section 35 ft. from the south end of basin; and the other section 635 ft. from the south end of the basin, nearly over the effluent pipes, and at three different points on each section; one point near the west side of the basin, a second point on the north and south center line of the basin, a third point near the east side of the basin. At each of the points on each of these two cross sections, three samples of water were taken, one at the surface, one 5 ft. below the surface, and the third 10 ft. below the surface, at an elevation somewhat above the top of the three effluent intakes along the north side of the basin. The average surface turbidity of the first section, near the south end of the reservoir, was 36 parts per million (silica standard); mid-depth turbidity, 42; bottom turbidity, 39. On the fourth section, 635 ft. from the

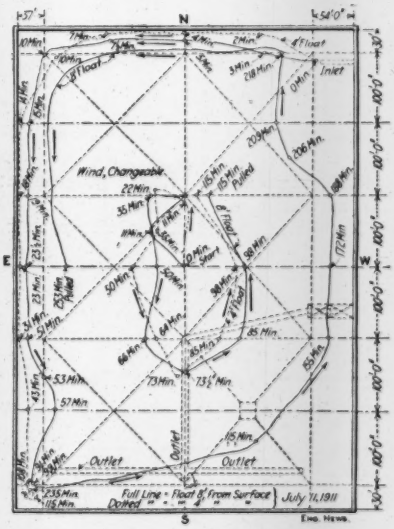

FIG. 6. SKETCH SHOWING TRAVEL OF WATER CURRENT IN SETTLING BASIN, KANSAS CITY, MO., JULY 11, 1911

(Elevation of water, 45. Rate of pumping, 42,000,000 gal. per day).

south end of the basin and almost directly over the effluent intakes, the average surface turbidity was 25 parts per million; mid-depth, 27; bottom, 29.

These results indicate an improvement of the water between the influent and the effluent pipe of an average of 12 parts per million. The average reduction of turbidity over the effluent pipes from the surface downward was about four parts per million.

In addition to these observations, float observations were made at a later date in order to demonstrate the character and extent of circulation in the basin. These observations are shown by Fig. 6.

The first series of floats was started at the influent pipe at the southwest corner of the basin, the controlling vane of one float being 8 ft. below the surface of the water. The deeper float made the entire traverse of the outer perimeter of the basin in 218 minutes and was finally taken out of the water at the end of about four hours, having doubled on its path, keeping near the outer perimeter with a tendency to approach the center of the basin. The 4-ft float reached the northeast corner of the basin and circled around in a small eddy.

Another series of floats, of the same depth respectively, were started at the geometrical center of the basin, circled around the starting point with a tendency to move from the center to the perimeter of the basin.

There was nothing in the results of these observations to indicate that bafflewalls or any similar device of directing the circulation of the water would improve the physical conditions, nor was there sufficient variation in the turbidity between the surface and the bottom of the reservoir to warrant a change in the method of taking water from the basin. Usually, the turbidity of the water in the new basin is less than at the time of the observations above described. Both before and since the recorded float observations, similar observations have been made which indicate a complete swing of the water, conforming practically to the circulation indicated on Fig. 6.

The cost of this settling basin was $156,789, an amount which may or may not be increased somewhat when a claim of the contractor for overhaul is finally adjudicated. Burton Lowther, as constructing engineer, rendered highly efficient service throughout the entire work, as also did C. F. Bartholomees as chief draftsman. The operation of the water-works is under the Board of Fire and Water Commissioners, composed of John P. Tillhof, E. I. Farnsworth and George C. Hale, with S. Y. High as chief superintendent.

The Work of the U. S. Reclamation Service is governed by "Service Orders," issued by the Secretary of the Interior and the Directors. The Supervising and Project Engineers also issue "Service Orders" covering the work in their charge. The briefest on record, recently issued by the engineer of the Truckee-Carson project, is as follows:

SERVICE ORDER 1912

The Governor of Arkansas says: "Do what you have to do with what you have to do it with."

Come on; let's do it now.

An African Freight Cableway

By C. A. Tupper*

To get valuable timber down from the Usambara Mts. in German East Africa, a cableway had to be built. The line is 5⅛ miles long and has several notable features among which are the loading and unloading stations, two angles in the line, and a span of 2950 ft.

In the Usambara Mountains of German East Africa extensive forests of valuable cedar grow on a lofty plateau, the mean elevation of which is about 6600 ft. above sea level. The timber land is made very difficult of access on the side towards the sea, by mountains, which rise almost perpendicularly from the plain to a height of nearly a mile. From the edge of the forests at New Hornow, where sawmills are situated, to Mkumbara, the nearest railway station on the Pagnanis plain, the air-line distance is 5⅛ miles. For conveying material between these two points a cog road, or any other kind of surface line, was out of the question and a cableway was decided upon. This article describes the line built, and mentions some of the engineering difficulties that had to be overcome. The entire system was constructed by Adolf Bleichert & Co., of London and Leipsic, for the firm of Wilkins & Wiese, of Tanga, who have the concession from the colonial government for marketing the timber.

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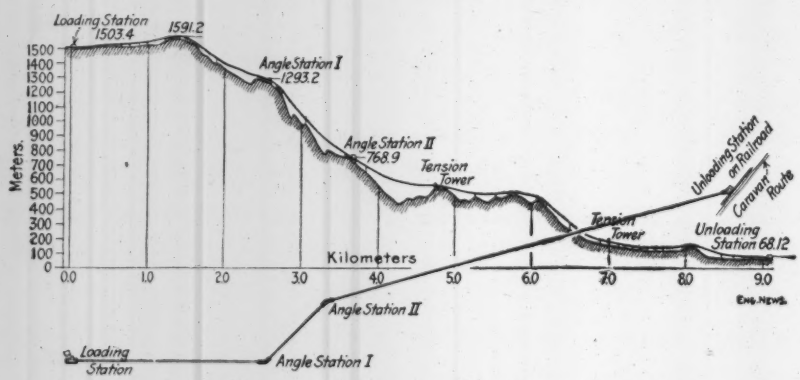


FIG. 1. PLAN AND ELEVATION OF THE MKUMBARA-NEW HORNOW AERIAL TRAMWAY

The elevation and plan of the system, showing the location of the two angle stations which were found necessary, are given in Fig. 1.

The wire ropeway begins at the New Hornow mills, where the loading station, Fig. 2, is located. Here the driving mechanism and the brake regulator are also installed. The plan and elevation of the station are shown in Fig. 3. In the left of the foreground of Fig. 2 the first structural supporting frame, on concrete foundations, is seen. At the right is one of the mill buildings and on the ground are lying logs of the kind carried by this aerial line.

The track has a gradual rise from the loading station of about 295 ft., reaching the maximum elevation of 5220 ft. above sea level or 4995 ft. above the unloading station at about three-quarters of a mile out from the mills.

In order to keep on a tangent, it was necessary to excavate when leaving the edge of the plateau. As this involved only the excavation of a firm, clay soil, no especial difficulties were presented, but measures had to be taken to suitably protect the foundations of the line supports from washouts caused by heavy

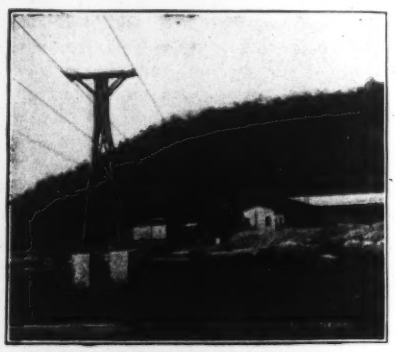


FIG. 2. LOADING STATION AT NEW HORNOW

tropical rains. As the most effective means to this end, the bottom of the cut (shown in Fig. 4) was given a decided slope towards the plain and provided with side ditches having lateral trenches to them in the front and rear of the towers. The profile of the aerial line follows the bottom of the cut, both having an inclination of 1 on 2.

The formation of the mountain range made it necessary to find sites for at least two angle stations to avoid spans of about 6600 ft. The cableway leaves the plateau, and is held on a tangent until it finds support on the side of a cone-shaped peak standing out from the main range. Here the first of the angle stations, shown in Figs. 5 and 6, has been arranged. Its construction however, was not without difficulty. In order

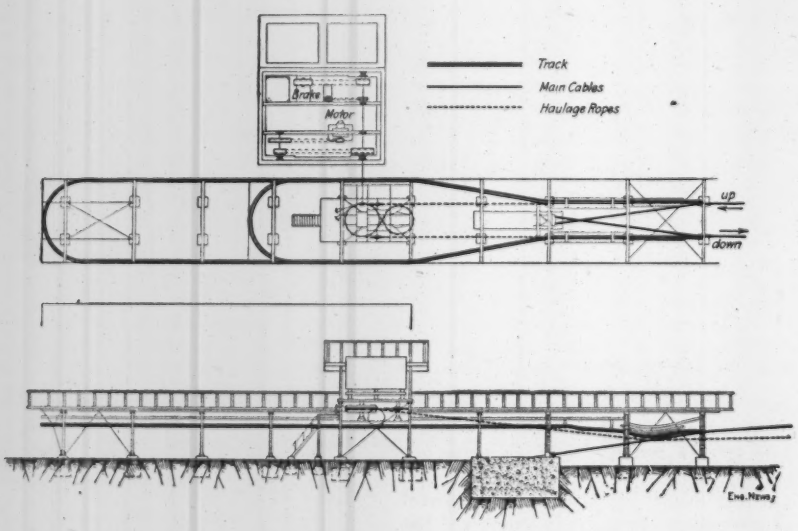


FIG. 3. PLAN AND ELEVATION OF LOADING STATION, MKUMBARA-NEW HORNOW AERIAL TRAMWAY

to bring in the line properly, considerable blasting was necessary, and the rock was very treacherous. It was not only crumbly but the strata ran in two directions, and slides were frequent. The difficulty was finally overcome by a strong wall facing and concrete filling. The station itself is now sheltered under a projecting knob, where it cannot be harmed by any slip above.

The main cables for the first section of the line are anchored at the loading station and the tension regulated in the first angle station by a weight of 16 tons for the loaded cable (descending) and 13 tons on the unloaded one (ascending side). The tension weights consist of iron frames filled with concrete cubes. The main cables for the second section are anchored in this station. The haulage rope of the first section passes through to the second section and is guided through the station on sheaves. The station has not been arranged for automatic operation; labor for transferring the carriages is plentiful and cheap.

The section below the first angle station is of interest, from its gradient of 41° or 1 on 1.15, which is 86.9%. This gradient is exceeded by only a few gravity cables in Canton Tessin and by the Wetterhorn elevator near Grindelwald, the latter having a gradient up to 200% or about 87° (see ENGINEERING NEWS, July 22, 1904).

In Fig. 7 may be seen a load of hewn cedar on its way down the mountain-side over the steepest stretch of line, and a steel rail which is being sent up.

From the first angle station to the second, the line is carried in two spans of about 985 ft. each. One of the supporting towers erected in this section is approximately 100 ft. high. Between the two stations the haulage ropes must be guided as far as possible from the main cables so that they will not be lifted and catch on the shoes of the supports under sudden changes due to high tension. For this reason the shape of the latter had to be varied from the usual design. Fig. 8 shows a support, just ahead of the second angle station, and which has specially shaped cable shoes about 4 ft. in length. Easily renewable cast-steel linings are bolted to these shoes and a guard extends over the cable at the center so that it cannot spring off. These have been provided elsewhere when there was similar risk. Such precaution has enabled these ropes to be drawn down more than would have been possible, otherwise.

For the second angle station, a for the first, extensive blasting and expensive foundation work were necessary. This station, shown in Figs. 7 and 10, has a location inferior to the other so far as protection against land slides is con-

FIG. 4. EXCAVATION FOR CABLEWAY AT EDGE OF NEW HORNOW PLATEAU

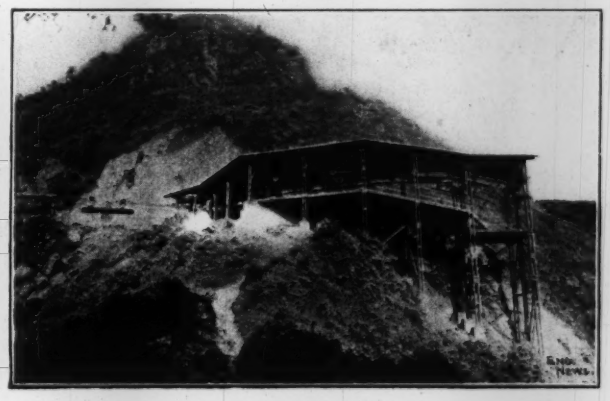


FIG. 5. ANGLE STATION NO. 1

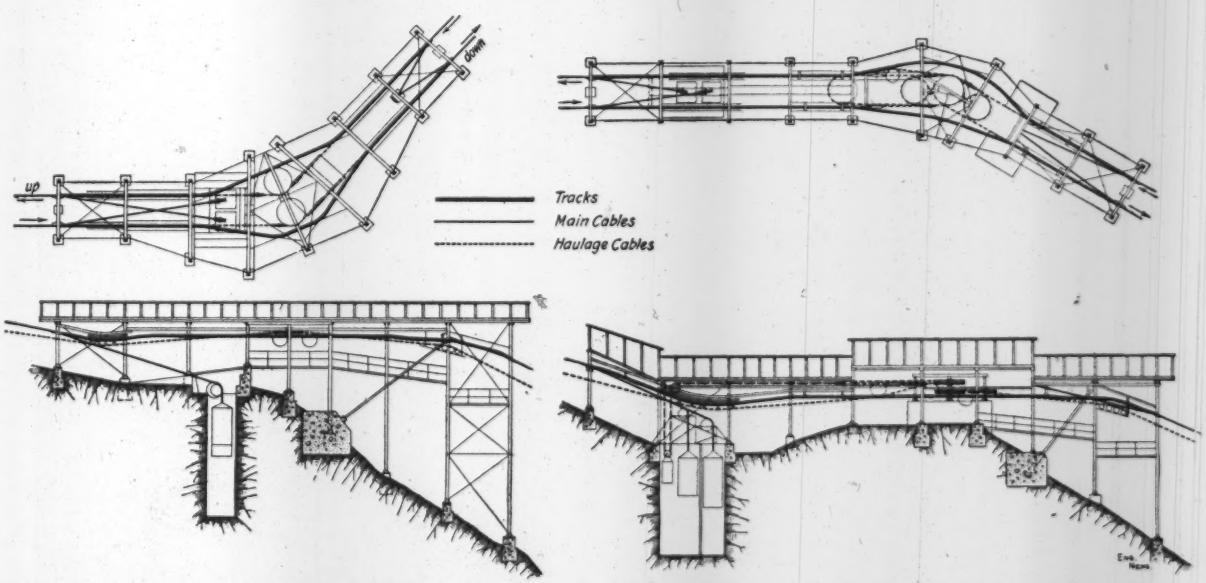


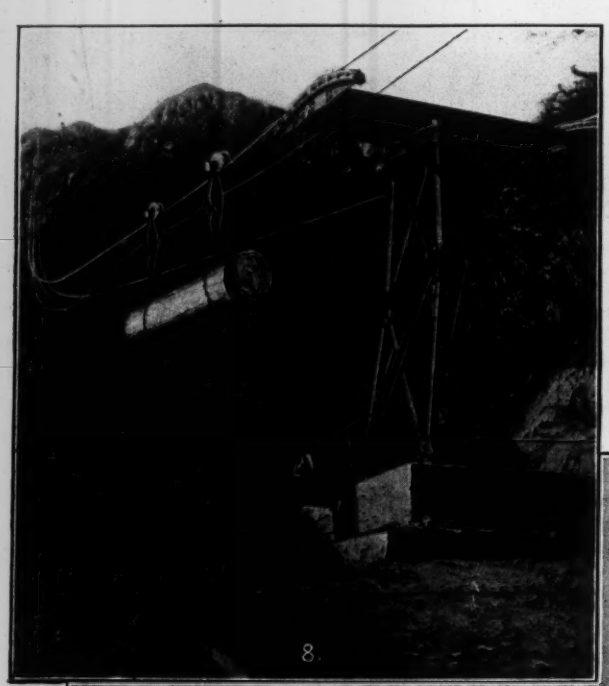
FIG. 6. PLAN AND ELEVATION OF ANGLE STATION NO. 1

FIG. 10. PLAN AND ELEVATION OF ANGLE STATION NO. 2

cerned, but the contour of the mountain slope offered no better choice except at the expense of a greatly lengthened span. The main cables for the second section had to be tightened at this point, and, in order to provide room for the tension weights, a pit had to be excavated in solid rock.

The haulage rope from the loading station at New Hornow terminates in the second angle station, but it is connected with the rope on the third section leading to the unloading station at Mkumbara, so that the two ropes are constrained to move together. Hand braking was not considered reliable enough for the continuation of the run down into the valley, and it was therefore arranged to have the brake regulator at the loading station also govern the last section of the haulage rope. Owing to the smaller drop in that section, there was also the liability of a tie-up if the traffic up should happen to be large and light down. The haulage rope of the upper sections is guided around a sheave on the shaft of the lower rope; the first rope then goes over its own return sheave fitted in a tension frame, the necessary tightening being effected by means of weights. Manual labor is also used here, as above, in passing the carriages from one section to the other.

Below the second angle station is a deep valley, which is crossed with a span of some 2950 ft., having a drop of 660 ft. This span is shown in Fig. 11. At about 6.1 km. from New Hornow, some 2700 cu.yd. of rock excavation had to be made for six towers, about 33 ft. apart. Towards the south the strata dip 10° to 15°, with fissures inclined towards the



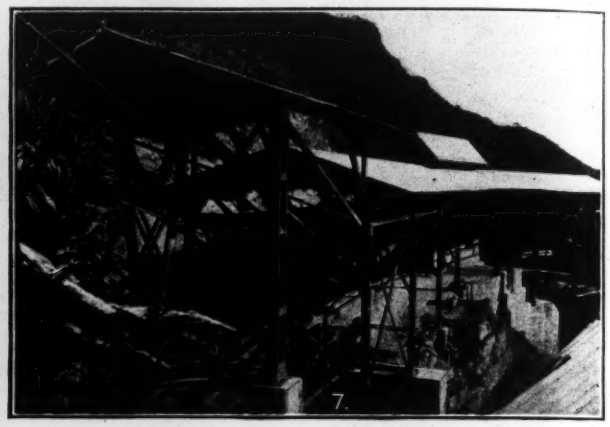


FIG. 8. CABLE TOWER WITH SPECIAL CABLE SHOES AND ROPE GUIDES

FIG. 7. ANGLE STATION NO. 2

FIG. 9. DESCENDING AND ASCENDING LOADS ON THE STEEPEST GRADIENT OF THE MKUMBARA CABLEWAY

west at about 45°; hence, with the first rainy season, frequent slips took place, carrying away large masses of rock and earth and destroying the supports. In re-erecting them and insuring against future disturbances, three times as much material had to be cleared away.

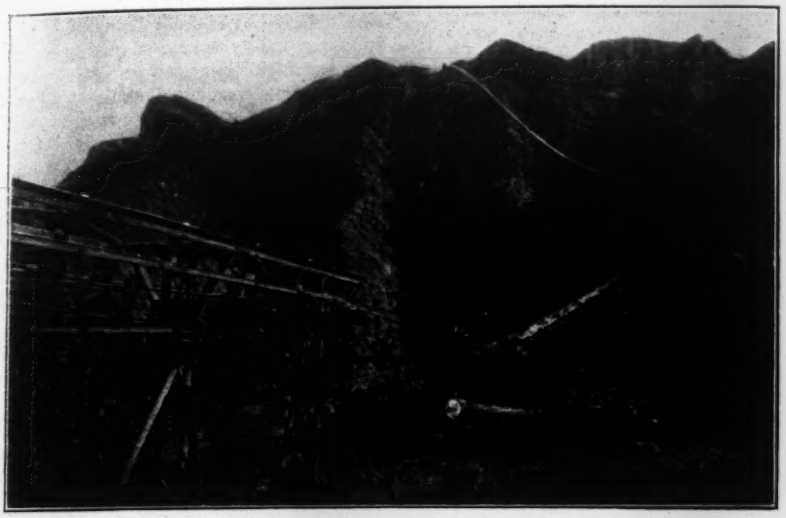


FIG. 11. A SPAN OF 2950 FT., MKUMBARA CABLEWAY

Throughout the construction of the line, the supports have been kept substantially of interchangeable design, so that few spare parts have to be kept on hand.

At the unloading station there is a raised platform, from which the logs can easily be rolled into railway trucks. There is also a moving table, which is run under the aerial carriages and raised by a simple hoist to a position just under the logs, timbers or boards, so as to take the load when the carrier chains are loosened. In unloading logs, the table is then tilted towards the railroad cars and the logs are simply rolled off.

On account of the long spans, and the heavy changes in the drop of spans, the haulage rope on the third section is subject to extreme fluctuations in tension; therefore it became necessary to fit the sheaves with regulating weights in a tower at the unloading station, so as to allow proper movement. (See Fig. 12.)

The aerial "cars," which are designed to carry logs up to 46 ft. in length, and weighing a ton, consist, each, of two carriages with no connection other than that of the haulage rope and the load itself. These are equipped with a patented coupling apparatus, the gripping power of which on the haulage rope is increased on gradients, detents being provided right and left of the hanger-pins and against which the hanger-stay bears on inclination. The hangers are very lightly designed, but are used with a counterweight, and have the required stability when running without load.

In the operation of the line, a special electric-motor drive and brake regulator, shown in Fig. 3, were necessary. This was partially due to the fact that the heavy service of a log-carrying line, because of the heavy single loads, was here made heavier by the use of the line for up-traffic. The possible combinations of load and transit to be provided for are manifold; for example, if only a few of the loads on the way to the railroad happen to be on the rising section between New Hornow and the highest elevation, without a corresponding up-traffic a very considerable capacity must be absorbed by braking. The differences between a positive and a negative capacity are comparatively small for ordinary traffic, with experienced men at each end of the line; but the possibility of excessive variations had to be taken into account. During the trial run, actual differences in capacity of plus and minus 25 hp. were registered. A variable-speed motor of 50 hp., with large overload capacity, was considered ample for any contingency in maintaining control over the line, with the brake apparatus described below. The motor is belted to the driving shaft of the system.

Besides the winding drum, there are two large band brakes fitted to the haulage shaft. In stopping the line both these brakes, which together can absorb 100 hp., are tightened. During regular operation they are disengaged, as the regulation of the speed is automatically effected by the brake regulator.

This regulator is a hydraulic type driven by a belt from counter-shafting and comprises a rotary pump and balanced throttle valve. The pump takes water from a reservoir below, forcing it back through the passages of the governing valve. This valve is actuated by a centrifugal regulator driven by a belt. As soon as the speed of the countershaft increases with a reduced stress on the haulage rope, the loads fall on the motor and the throttle slide closes to check the movement of the pump which then acts on the shaft as a strong brake. A high-level reservoir, with ample capacity, is built above the loading station to keep the brake tank regularly supplied. For the dry season there is also a low-level concrete reservoir, with service pump connected to the high-level tank.

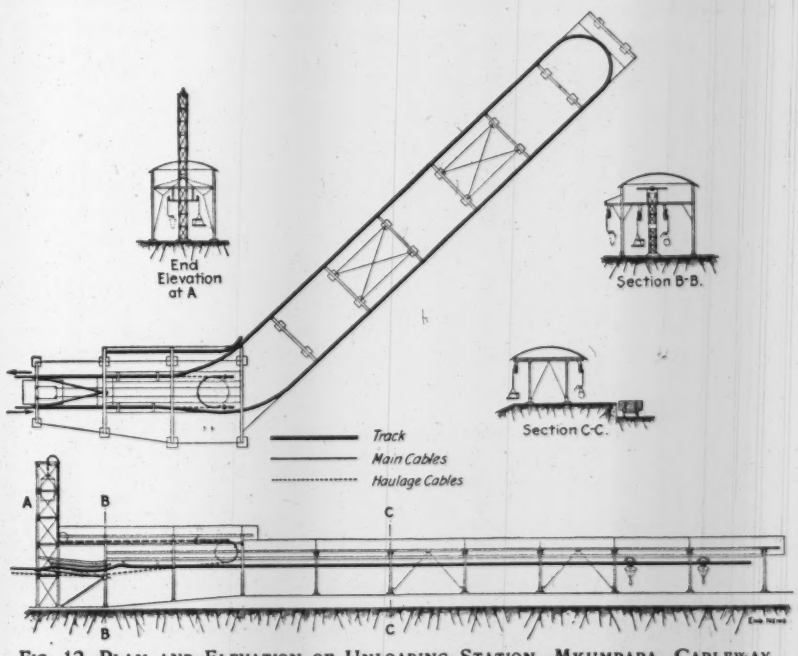


FIG. 12. PLAN AND ELEVATION OF UNLOADING STATION, MKUMBARA CABLEWAY

The line has now been in service about 18 months with noteworthy success. In addition to the timber, it takes passenger traffic and it also brings down to the plantations at the foot of the mountains, the fresh meat, vegetables and other provisions which can only be produced in the temperate climate of the high plateau. The aerial tramway is thus of considerable importance in the development of the locality.

It is interesting to note that, owing to the danger from wood-destroying ants, all stations and supports had to be made of steel construction. For the poles of the accompanying telephone line, Mannesman tubing was used. Such factors together with the difficult transportation of material along the line made the cost of the undertaking relatively high. The construction was carried out by European engineers, with the assistance of unskilled natives, who had to be brought long distances from the interior as the Massai in this district will not work.

Speaking Up for Engineers—This caption appeared over an editorial in a recent issue of Engineering News in reference to the action of the Brooklyn Engineers' Club in adopting resolutions urging the Governor of New York to select for appointment a member of the engineering profession when the next vacancy occurred in the Public Service Commission of New York. The point is well taken.

At a meeting of the Engineers' Club of Baltimore, Md., Jan. 4, 1912, the following resolution was unanimously adopted:

Whereas, there is now a vacancy in the Public Service Commission of Maryland, by reason of the resignation of the chairman of the commission; and there will be a vacancy in May, 1912, by the operation of the law creating the commission; and the problems presented to this body for investigation and determination in the ultimate analysis are predominantly engineering ones; and the tendency in other communities is to recognize the value of an engineer commissioner; we are convinced of the desirability of the selection of an engineer for one of these vacancies, both from the point of view of the value of the services of an engineer member to the community, and from the view of the right of a large and useful profession to representation on this board; therefore, be it resolved that an engineer should be appointed to one of these vacancies.

A copy of these resolutions was sent to the Governor and the Governor-elect of the state, and the same week the Governor in making the two appointments did select an engineer for one of them. . . . . .

Hired technical brains will always be needed by courts and commissions, but a better quality of brains is likely to be hired if the employer himself has sufficient technical knowledge to appreciate the intricacies of the problems to be solved.

Engineers are notoriously over-modest. They hesitate to speak up even though the interests of the profession are at stake. Let their professional organizations recognize the duty to exert their influence toward intelligent and economical administration of public works.—Journal of the Engineers' Club of Baltimore, February, 1912.

The New Public Health*

By H. W. Hill†

The statement that there is a "New Public Health" may shock those who, although familiar with recent changes in scientific thought, yet have not fully realized what those changes mean; but the shock will be far greater to those who have not appreciated that changes were going on.

The purpose of this article, the first of a series, is to formulate for both groups, the unconscious progressive and the unconscious conservative, a brief statement of the essential principles of modern official public-health work. To those who may feel skeptical as to the fairness of this exposition, the writings of Chapin, the great American pioneer of modern public health, of E. O. Jordan, and of M. N. Baker, may be offered as bearing directly upon these questions, while the whole of modern technical public-health literature may be offered as indirect evidence.

The old principles have merged gradually into the new, in keeping with the experiments, observations, and conclusions of many investigators in many individual sciences related to general public health. Within official public-health circles, bacteriology, clinical observation and mathematics have furnished most of the reconstruction. The bacteriologist, the epidemiologist, and the vital statistician, sometimes working together, more often alone, in the dark and even at cross purposes, have nevertheless all reached the same point, and today each finds his co-workers beside him. Much of the work done has consisted in clearing away the fallacies built up by tradition, but construction-work has gone on also, and it is now possible to formulate the results.

The essential change is this: the old public health was concerned with the environment; the new is concerned with the individual. The old sought the sources of infectious disease in the surroundings of man; the new finds them in man himself.

The old public health sought these sources in the air, in the water, in the earth, in the climate and topography of localities, in the temperature of soils at 4 and 6 ft. deep, in the rise and fall of ground-waters; it failed because it sought them, painstakingly and exhaustively, in every place and in every thing *where they were not.*

The new public health seeks these sources—and finds them—among those infective persons whose excreta enter, usually by the mouth, the bodies of other persons.

The old public health failed to find the sources of infection; it also failed in most instances to find the routes of transmission. It is true that public water supplies were detected as at times acting thus, but milk was hardly suspected twenty years ago, and flies, suggested in 1887,* were not seriously considered until the Spanish-American war; mouth-spray† and hands have been only recently recognized as important. On the other hand, dirty clothes, bad smells, damp cellars, leaky plumbing, dust, foul air, rank vegetation, swamps, stagnant pools, certain soils, smoke, garbage, manure, dead animals, in fact all the things physically, sensorially, esthetically or psychically objectionable, were lumped together as "unsanitary" without much distinction of "source" or "route," and were regarded as a sort of general "cause of disease" to be condemned, wherever found, "for fear of epidemics."

It was taught that infectious diseases "generated" in the foul, ill-smelling, unventilated, sunless hovels of the slums. In the vogue of those days, "the slum-dwellers live like pigs, and thereby invoke the coming of smallpox, scarlet fever, typhoid fever, diphtheria." When these diseases invaded the home of the well-to-do, where this explanation was not seemly, a pinhole leak in some plumbing fixture accounted amply for diphtheria; rotten potatoes, forgotten in a dark corner of the cellar, for typhoid fever; scarlet fever was traced to a letter from a friend who had had the disease months before; smallpox to unpacking books used by a patient a quarter of a century previously; manure piles gave rise to cholera; and dampness to malaria, which was not recognized as transmissible at all. Yellow fever originated in impure water and was directly transmitted from person to person—a typical example of intense direct contagion; tuberculosis was non-infectious and hereditary; bubonic plague was banished from the Egyptian Cairo "simply by improving the ventilation of the city" (!)‡

Remedial and preventive measures, based on such beliefs in the omnipotence of environment, naturally sought to remodel the lives and immediate home surroundings of the whole population to conform with a vast array of alleged "sanitary laws of health." Yet he who seeks for a scientific demonstration of the relations existing between disobedience of these "sanitary laws" on the one hand,

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*From the Minnesota "Journal-Lancet" of Jan. 15, 1912. Other articles in the series of which this one forms the first will be published on the 15th of each month.

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*Wm. H. Welch: Address at the Annual Meeting of the Medical and Chirurgical Faculty of Maryland, 1887, quoted in "Sewage and Local Drainage."—Waring, 1889.

†By this is meant the fine droplets thrown out from the mouth in speaking, singing, laughing, sneezing, coughing, etc.

‡Parke's Hygiene, 1891; eighth edition. This was a standard work of 20 years ago.

and the incidence of disease and death on the other, will find only a "twilight zone" in which move vague shadows of traditional fear, shadows which, on probing, fade mistily away.

The New Public Health is not worried by elaborate theoretical possibilities, but concerns itself earnestly with practical probabilities. The occasional, unusual, bizarre routes of infection in the 1 per cent. of cases, do not distract its attention from the usual, practically constant, simple, ordinary routes concerned in the 99 per cent. Its main postulate is that the routes of infection are simply the routes of infected bodily discharges, which, again, are identical with the routes of ordinary uninfected discharges in ordinary life.

The old style "sanitary inspector" was expected to, and usually did, "condemn" everything in sight, from the garbage pail at the back door to the plumbing in the bathroom. But disease continued, because he was condemning, as a rule, so far as health was concerned, things largely "incompetent, irrelevant, and immaterial." What availed it that the garbage pail was emptied every day or a vent-pipe placed on the bath-water waste-trap, if the milkman delivered scarlet-fever infected milk at the door, or an unrecognized case of measles sat next the children at school?

The New Public Health sees in the garbage pail merely a place where flies are fed and, possibly, bred. But the flies cannot carry infection *if infected discharges are not accessible to them.* "Defective plumbing," such a nightmare twenty years ago, has been conclusively shown to have nothing to do with disease-generation or disease-propagation whatever, unless perchance there be actual gross leakage of infected sewage. The unventilated front parlor could not produce tuberculosis in a hundred years; diphtheria does not develop from the family well; and typhoid fever (in Minnesota) is but seldom properly traceable to that source either.

The modern public-health man cares nothing, so far as restriction of disease and death is concerned, for the dirty back yard or the damp cellar in themselves, but only as they may enter into the transmission of infected discharges. Then, at once, they become of vital importance. The sanitary inspection of the modern sanitarian, so far as relates to infection, begins and usually ends with the search for (a) the infected individual; (b) the routes of spread of infection from that individual; (c) the routes of spread of the ordinary excreta of ordinary uninfected individuals to the mouths of their ordinary associates in ordinary life. These latter are sought for, not because of danger from such uninfected discharges, but rather because infected discharges, introduced into and following the same well beaten paths, will necessarily reach the same mouths. To locate all the infective persons and to guard all their discharges would be wholly sufficient, but since this cannot always be done perfectly, it is well to guard also the routes which unlocated infection may take.

Has environment, then, nothing to do with infectious diseases? Environment acts in two ways: (1) Unequivocally and without reserve, such environments as permit or encourage or, still worse, necessitate the exchange of human excreta in ordinary life, contribute in the long run to the spread of disease since they insure a similar exchange of infected excreta so soon as the latter are introduced.* Let us take one environmental evil, overcrowding, as an example. Overcrowding, if combined with lack of discipline and order, and lack of facilities for washing, especially for the washing of hands, contributes to the spread of infectious diseases; but not in itself, nor at all, unless infection be introduced into the community. Then overcrowding, because it tends to insure exchange of human excreta, tends also to insure that the infection will spread rapidly and extensively. But overcrowding, if the overcrowded be disciplined, intelligent, and take proper precautions to avoid exchange of excreta, does not necessitate the spread of infection, even if it be introduced. On the other hand, infection may spread, and frequently does, without overcrowding, if the essential factor of such spread exist, i.e., the transmission of infected excreta.

(2) Environments that are bad from a physiological standpoint (bad for the body, regarded as a delicate biological machine) are often held to act in spreading infection indirectly by "depressing vitality" to an extent which makes infection, if received, more likely to develop (and if it develop, more successful in injuring the body). It must be said, however, that the evidence on this point, except perhaps that relating to tuberculosis and pneumonia, is very slight. It is a debatable question whether or not overcrowding "depresses vitality" in the direction of increasing susceptibility to infectious diseases, whatever its effects may be in encouraging "general debility." It is a very debatable question whether or not "poor ventilation" to which the effects overcrowding are often attributed, can or does "depress vitality" in the direction of lessening resistance to infectious diseases, whatever bad effects it may have on mental vigor or physical activity. It is true that there is evidence that such environments as lead to extremes (beyond the limits of compensatory adjustments by the body forces) of malnutrition, of temperature, of fatigue, and of alcoholism, probably may have an effect in insuring the development of infection, which under better conditions might be negatived by the body forces. Especially may the influence of bad physiological environment be recognized when the dose of infection is small, infrequent, or low in virulence. But starvation, unsuitable temperature, fatigue, alcoholism, alone or together, cannot induce infection, nor will the converse conditions, alone or together, offset the effects of infection when the dose is large or frequently repeated or of high virulence.

*An excellent exposition of this effect of environment on the spread of disease is given by Chapin in the Report of the Providence Health Department for 1910.

The Uses of the Great Lakes

Through an inadvertence, the figures showing the relative water levels of Lakes Michigan, Huron and Erie, from 1860-1909, were omitted from Mr. F. G. Ray's discussion on p. 357 of our issue of Feb. 22, 1912, of Prof. Williams' article on "The Uses of the Great Lakes." The figures are reproduced herewith.

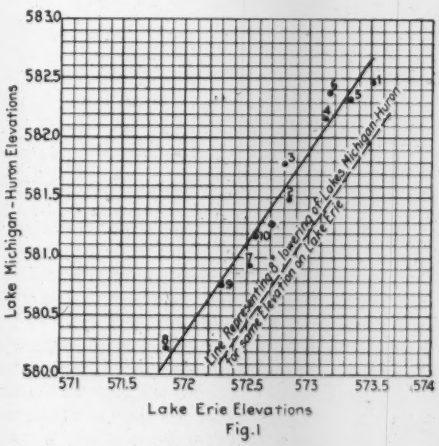

Fig. 1

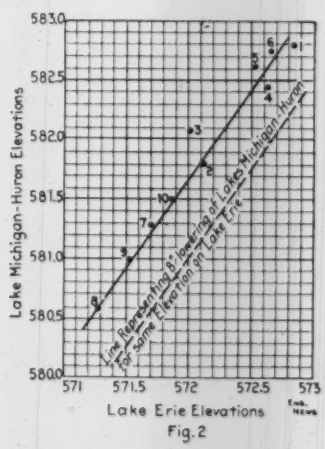

Fig. 2

FIGS. 1 AND 2. RELATIVE WATER LEVELS OF LAKES MICHIGAN-HURON AND LAKE ERIE, 1860-1909

California Evaporation Records

By Edwin Duryea, Jr.*

Two series of evaporation records are reported. The first series covers observations at Lake Tahoe, extended through about six years, but with many gaps. The second series, in the Santa Clara Valley, was less extensive in years but more nearly complete in daily observations, besides which there were 11 observing stations, of which three were floating-pans and eight land stations. The seven tables include both summaries of the original records and "safe" evaporation figures for the localities in question, deduced therefrom.

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The article on evaporation, by Mr. Chas. H. Lee, in your issue of Oct. 12, 1911, is a valuable contribution to the subject. Such information is rather scarce and difficult to obtain when wanted, and as I have some additional information on evaporation which I think will be of general interest to engineers, I submit it herewith. The data consist of:

(1) About six years' evaporation of Lake Tahoe worked up by me in person from the daily records taken by the U. S. Reclamation Service, obtained from the then Supervising Engineer, Mr. L. H. Taylor.

(2) Two years evaporation from eight land pans and three floating pans in Santa Clara Valley, a few miles from San José, Calif.

No scientific or laboratory exactness is claimed for either, but as observed and worked up, the final deductions are believed to give a somewhat large or safe evaporation for the sections of the country represented.

As of some interest in this connection the following mean annual temperatures are given, these being taken from "California Climatology," by Prof. A. G. McAdie, of the U. S. Weather Bureau.

MEAN TEMPERATURES (F°) AT SAN JOSE, CALIF. (100 FT. ELEVATION), ABOUT 12 MILES FROM LAGUNA SECA, FOR THE 26 YEARS, 1874–1899

	Mean	Minimum	Maximum
Jan.	+48.2	+18	+78
Feb.	50.7	24	82
March	53.6	26	86
April	56.4	29	87
May	60.1	32	104
June	65.5	35	104
July	66.7	41	100
Aug.	66.4	42	101
Sept.	64.7	37	98
Oct.	60.2	32	90
Nov.	54.1	25	84
Dec.	50.1	22	78
Mean annual.	+58.1	+18	+104

MEAN MONTHLY AND ANNUAL TEMPERATURES (F°) AT TRUCKEE, CALIF.,* (5818 FT. ELEVATION), FOR THE 30 YEARS, 1871–1900

Jan.	+25.3	July	65.4
Feb.	28.3	Aug.	63.4
March	32.9	Sept.	55.9
April	40.0	Oct.	45.1
May	48.4	Nov.	36.5
June	57.4	Dec.	28.7
		Mean annual.	+43.9

The Lake Tahoe records were made use of in a study of a 60,000-hp. power project in the Sierras, and the Santa Clara Valley records were utilized in a very careful investigation for city-water supply. The deductions from each set of records were drawn with the idea of being high and safe as governing net stream-flow production. Both the projects mentioned have since been combined with other interests in the United Properties Co., a recently organized two-hundred-million-dollar California corporation.

Table I shows the Lake Tahoe records by months and years, including the results of actual observations and the deductions therefrom to make good the gaps in the records. Tables II and III are based, in turn, upon Table I, and show assumed safe yearly and safe monthly evaporations, respectively.

*Truckee is on the Southern Pacific Railroad, about 12 miles north of the northern end of Lake Tahoe and of evaporation pan observed.

The evaporation from May, 1900, to December, 1901, is copied direct from p. 34 of Water Supply and Irrigation Paper No. 68, U. S. Geological Survey, except that the evaporation for May, 1900, is filled in as the mean of all the Mays because the evaporation observations were not begun until May 17.

All the evaporations since January, 1902, were worked up by the writer in person from copies of the original daily observations furnished him by Mr. L. H. Taylor, then supervising engineer for Nevada of the U. S. Reclamation Service, alto author of Paper No. 68, mentioned above.

The evaporation was observed by measurements in a floating pan near the outlet of the lake, the pan being 2 ft. square by 2 ft. deep, and being protected as well as practicable from the heavy waves of the lake. Quoting from Mr. Taylor's paper, already mentioned:

> A finely divided scale was placed in the pan, and daily readings were taken about the same hour each day by Mr. J. U. Haley, general freight and passenger agent of the Lake Tahoe Ry. & Transportation Co. The pan was at all times kept filled to within 1 or 2 in. of the top, and was floated by means of a timber frame, which also served as a protection from waves and drift, so that the water level inside and outside was about the same. The depth of water in which the pan was anchored was about 6 ft., and the water in the pan was fully exposed to wind and sun.

While the evaporation observations were nominally taken daily, there were actually many interruptions to the continuity of the records. The evaporation pan was a number of times dislodged or damaged by storms (waves), was often frozen over, and its reading was often made impracticable by stormy weather—rain or snow. In only three months (Julys of 1904, 1905 and 1906) were readings taken every day, and in only a few months was it practicable to take a large proportion of the daily readings (see table). The record as a whole hence consists of more or less disconnected daily evaporations, from which, by making use of the observed daily evaporations just preceding and just following each gap in the record, and of the notes as to the weather, the lacking evaporations may be estimated. The deduced monthly evaporations are hence dependent to a large degree on the judgment of the person working up the records.

The general rule in filling gaps in the records was to assume the average daily evaporation of the lacking period to be equal to the average of the daily evaporation just preceding and that just following the gap—unless the gap was due to stormy weather (rain or snow), in which case only one-half the average of the preceding and following daily evaporations was used. The notes below the table show this treatment quite fully [omitted here].

In comment on the accuracy of the deduced monthly and yearly evaporations, those from May, 1900, to December, 1901, were checked by the inflow and outflow of the lake from Aug. 19 to Sept. 18, 1901 (see Paper No. 68, p. 35), with the following conclusion by Mr. Taylor:

> It is therefore believed that the observed evaporation at Lake Tahoe, since May 17, 1900, will very closely approximate the actual loss from the lake surface from that source, as well as the probable evaporation in other lakes or in storage reservoirs situated at about 6000 ft. altitude in this portion of the Sierras during the period over which the record extends. Of course evaporation is not constant from year to year, but the variation should not be great in this region, and as the summer of 1900 and the summer and fall of 1901 were unusually dry and windy, the evaporation during that period can probably safely be considered a maximum.

In similar comment on the monthly and yearly evaporations since January, 1902, as worked up by the writer, it may be said that since they were worked up with care, and since the evaporation during stormy weather, into air producing moisture and hence at saturation, is assumed equal to one-half the evaporation in dry weather, therefore the monthly evaporations deduced are believed to be greater than the actual, and hence conservative as giving a somewhat excessive evaporation from the lake and from similarly situated reservoirs.

As already stated, the Santa Clara Valley studies consist of records of evaporation from eight land and three water or floating pans in the Santa Clara Valley, near San Jose, Calif., and of deductions therefrom.* The basic table (omitted here) gives for each of the 11 stations, for each month of the

*The plate or blueprint (about 1½x5 ft.) reporting these data included seven tables, some of which are necessarily omitted here.—Ed.

TABLE I. MONTHLY AND YEARLY EVAPORATIONS AT LAKE TAHOE, CALIF. (ELEVATION 6225 FEET), 1899–1906, AS DEDUCED FROM DAILY OBSERVATIONS OF THE U. S. GEOLOGICAL SURVEY AND THE U. S. RECLAMATION SERVICE

Month	1899–1900 Inches	Per cent.	1900–1 Inches	Per cent.	1901–2 Observed Days	Observed Inches	Deduced Inches	Deduced Per cent.	1902–3 Observed Days	Observed Inches	Deduced Inches	Deduced Per cent.	1903–4 Observed Days	Observed Inches	Deduced Inches	Deduced Per cent.
Sept.	....	....	3.10	11	..	.....	4.12	16	24	2.80	3.40	10	25	3.88	4.27	14
Oct.	....	....	2.15	7	..	.....	2.65	10	0	....	*(3.09)	9	24	2.78	3.33	11
Nov.	....	....	1.38	5	..	.....	2.09	8	0	....	*(2.15)	6	9	0.64	2.53	8
Dec.	....	....	1.33	5	..	.....	1.44	6	4	0.25	0.85	3	23	1.18	1.44	5
Jan.	....	....	0.84	3	9	0.35	1.02	4	7	0.35	0.70	2	18	0.72	1.17	4
Feb.	....	....	0.70	2	4	0.15	0.87	4	0	....	0.84	3	7	0.20	0.47	1
Mar.	....	....	0.77	3	0	.....	*(1.24)	5	13	1.15	1.88	6	1	0.10	0.56	2
Apr.	†	....	1.25	4	0	.....	*(1.85)	7	15	1.50	2.75	8	21	0.94	1.38	4
May	*(2.44)	....	2.42	9	5	0.30	1.08	4	28	3.05	3.20	10	24	2.70	3.19	10
June	3.80	....	3.35	12	21	1.90	2.45	10	24	3.40	3.90	12	26	3.24	3.80	12
July	4.00	....	*(4.42)	16	29	3.20	3.40	13	10	1.42	5.62	17	31	4.42	4.42	14
Aug.	5.15	....	6.50	23	26	3.20	3.45	13	29	4.36	4.66	14	25	3.82	4.73	15
Year	....	....	28.21	100	..	.....	25.66	100	..	.....	33.04	100	..	.....	31.29	100

Month	1904–5 Observed Days	Observed Inches	Deduced Inches	Deduced Per cent.	1905–6 Observed Days	Observed Inches	Deduced Inches	Deduced Per cent.	1906–7 Observed Days	Observed Inches	Deduced Inches	Deduced Per cent.	Minimum Inches	Minimum Per cent.	Maximum Inches	Maximum Per cent.	Mean of all months Inches	Mean of all months Per cent.	Mean of all per cents., 1900–1 to 1905–6
Sept.	21	2.56	3.27	10	26	4.38	4.74	15	25	3.52	3.94		3.10 =	15	4.74 =	12	3.83	13	13
Oct.	15	1.62	2.86	8	29	3.66	3.82	12	29	3.44	3.70		2.15	10	3.82	9	3.09	10	9
Nov.	16	1.62	2.77	8	17	1.78	2.78	9	5	0.42	1.35		1.35	7	2.78	7	2.15	7	7
Dec.	18	1.06	1.59	5	22	1.58	1.85	6	0	....	0.62		0.62	3	1.85	5	1.30	4	5
Jan.	20	1.33	1.81	5	10	0.50	1.12	4	..	.....	.....		0.70	4	1.81	4	1.11	4	4
Feb.	17	0.95	1.30	4	3	0.18	0.98	3	..	.....	.....		0.47	2	1.30	3	0.86	3	3
Mar.	12	0.98	1.78	5	11	0.64	1.20	4	..	.....	.....		0.56	3	1.88	5	1.24	4	4
Apr.	22	2.08	2.46	7	14	0.83	1.42	4	..	.....	.....		1.25	6	2.75	7	1.85	6	6
May	15	1.64	2.50	7	17	1.64	2.26	7	..	.....	.....		1.08	5	3.20	8	2.44	8	8
June	23	3.12	3.57	11	13	1.49	2.39	8	..	.....	.....		2.39	11	3.90	10	3.32	11	11
July	31	4.76	4.76	14	31	4.30	4.30	14	..	.....	.....		3.40	17	5.62	14	4.42	14	14
Aug.	26	4.60	5.27	16	25	3.80	4.55	14	..	.....	.....		3.45	17	6.50	16	4.90	16	16
Year			33.94	100			31.41	100		.....	.....	100	20.52 =	100	40.15 =	100	30.51 =	100	100

† Observed May 17-31, 14 days = 1.83 in. * (....) filled in by using mean of all Mays, etc.

calendar years 1904 and 1905, the number taken, the observed evaporation, the deduced evaporation for days without corresponding records, and the sums of the observed and deduced evaporations, together with corresponding totals for each year. The next table [our IV] is a summary of the first one, by years. The next two tables of the original [omitted here] summarized the evaporations by months and by pans in inches of depth for each month and percentage of monthly to yearly totals and also restated the monthly percentage distribution by pans and by means for each group of pans. The last three tables of the seven [our Tables V, VI and VII] present the final summaries and deductions of the whole Santa Clara series of observations.

The object of the original seven tables based on the Santa Clara observations was to obtain a reliable local basis for evaporation losses in reservoirs, which would otherwise have been assumed; or mere assumption.

As a result of the work presented, yearly evaporations are justified which are only about three-quarters of what would otherwise have been assumed; or without the justification given by this study, the evaporation losses assumed would have been about one-third in excess of those adopted.

The pans were of galvanized iron, 3 ft. square by 12 in. in depth. The readings were taken at intervals of about a week and consisted of measuring the depth of water above a fixed spot in the pan to $\frac{1}{64}$ in. with an ordinary rule, both before and after replenishing the pan. To correct for rainfall, a rain-gage was located near each pan and was read simultaneously with the pan.

All the pans were so placed as to be well exposed to breeze and sun, and to be under good average evaporation conditions for the special locality.

Much difficulty was encountered in keeping up the pans. The land pans were more or less interfered with by cattle, which in some cases broke down the wire fence enclosing the pan, to drink the water; and the floating pans were at times swamped by waves from wind or interfered with by boys in swimming. A twelfth pan, a floating pan in the Coyote River, near Coyote, was early carried away by a flood and is not included in the records. The many interruptions in the records are due to such difficulties as have been mentioned.

No claim to scientific accuracy is made for the records. On the other hand, they were honestly taken with much care; 81% of the days in the two years and 89% of the inches were carefully observed; and the lacking 11% of the inches were filled in with much care, as described elsewhere, the operation requiring nearly three weeks' time of a careful man. The records as completed are believed to be sound and reliable and sufficiently accurate for all practical purposes. The evaporations finally adopted, somewhat larger than the observed, are believed to be safe and justifiable.

In order to render easier the task of drawing general conclusions, it is advisable that the gaps in each yearly pan-record be filled as accurately as practicable, so as to have complete yearly records. The causes of these gaps in the records are explained sufficiently in the foregoing statements. To fill these gaps two differing methods of deduction were used, the choice being determined by the nature of the special gap under investigation.

These methods are briefly as follows:

Method No. 1, for short periods (one day to three weeks).

Let

x'' = Daily rate of evaporation for the pan in question during the gap to be filled;

a'' = Mean of daily rates observed for same pan before and after the gap to be filled;

b'' = The daily rate observed for the same period in some corre-

TABLE II. SUMMATION OF YEARLY EVAPORATIONS AT LAKE TAHOE, CALIF., FOR 6 YEARS; AND ASSUMED SAFE YEARLY EVAPORATION

Year (Sept. to Aug., inclusive)	Evaporation, inches	Evaporation, per cent.	Per cent. departure from mean —	Per cent. departure from mean +
1900–1	28.21	92	8	
01–2	25.66	84	16	
02–3	33.04	108	....	8
03–4	31.29	102	....	2
04–5	33.94	111	....	11
1905–6	31.41	103	....	3
Mean	30.59	100	—24	+24
Assumed safe	36.0 =	117.7	....	+17.7

It should be noted that the assumed safe yearly evaporation is 90% of the sum of the maximum months of Table I, 40.15 in.

TABLE III. ASSUMED SAFE MONTHLY EVAPORATIONS, LAKE TAHOE, CALIF.

Month	Assumed per cent. distribution (= mean of all months)	Corresponding monthly evaporation in inches	Notes
Sept.	13	4.68	It should be noted
Oct.	10	3.60	that the assumed %
Nov.	7	2.52	distribution chosen
Dec.	4	1.44	above (mean of all
Jan.	4	1.44	months), differs
Feb.	3	1.08	hardly at all from
Mar.	4	1.44	the three other %
Apr.	6	2.16	distributions given
May	8	2.88	at end of Table I,
June	11	3.96	i.e., of the minimum
July	14	5.04	months, the maxi-
Aug.	16	5.76	mum months, and
Total year	100 =	36.00	the mean of all %'s, 1900–1 to 1905–6.

TABLE IV. SUMMATION OF OBSERVED EVAPORATIONS, SANTA CLARA VALLEY, CALIF.

	Coyote Valley Group				Laguna Seca Group								
	Land pans				Land pans						Floating pans		
Year	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6		No.
1904	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Days
Observed	311	48.04	343	49.11	362	53.60	351	61.38	306	45.21	223	37.57	259
Deduced	54	1.79	22	0.57	3	0.15	14	0.82	59	8.62	142	5.86	106
Total, year	...	49.8	...	49.7	...	53.8	...	62.2	...	53.8	...	39.4	
1905													
Observed	333	40.79	351	42.04	359	55.31	365	60.37	365	54.81	168	25.49	174
Deduced	32	5.93	14	3.72	6	0.11	...	.....	...	.....	197	17.60	193
Total, year	...	46.7	...	45.8	...	55.4	...	60.4	...	54.8	...	43.1	
Two Years													
Observed	644	88.8	694	91.2	721	108.9	716	121.8	671	100.0	391	59.1	431
Deduced	86	7.7	36	4.3	9	0.3	14	0.8	59	8.6	339	23.5	299
Total, two years	...	96.5	...	95.5	...	109.2	...	122.6	...	108.6	...	82.5	

	Upper Gorge Group											
	Land pans						Floating pan					
Year	No. 8		No. 9		No. 10		No. 11		Totals		Totals as per cents.	
1904	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Days	Inches
Observed	359	41.54	352	45.90	284	41.42	260	27.83	3410	484.4	85%	93%
Deduced	6	0.15	13	1.28	81	5.08	105	6.43	605	36.9	15%	7%
Total, year	...	41.7	...	47.2	...	46.5	...	34.3	4015	521.3	100%	100%
1905												
Observed	273	44.93	234	36.92	255	43.11	217	21.47	3092	459.8	77%	85%
Deduced	92	7.40	131	8.26	110	12.29	148	8.91	923	83.2	23%	15%
Total, year	...	52.3	...	45.2	...	55.4	...	30.4	4015	543.0	100%	100%
Two Years												
Observed	632	86.4	586	82.8	539	84.5	477	49.3	6502	944.2	81%	89%
Deduced	98	7.6	144	9.6	191	17.4	253	15.4	1528	120.2	19%	11%
Total, two years	...	94.0	...	92.4	...	101.9	...	64.7	8030	1064.4	100%	100%

TABLE V. SYNOPSIS OF OBSERVED YEARLY EVAPORATIONS, SANTA CLARA COUNTY, CALIF.; AND FLOATING-PAN EVAPORATION AS A PER CENT. OF LAND-PAN EVAPORATION

		1904			1905			
	Near-by rain-gage, no.	Inches evap-oration	Floating pan as per cent. of land pan: Pairs of pans	Means of groups	Inches evap-oration	Floating pan as per cent. of land pan: Pairs of pans	Means of groups	Means of two years inches = %
Coyote valley group	Coy.							
Pan No. 1, Weber, land	34	49.8	.....	49.8 in.	46.7	.....	46.2 in.	48.0
Pan No. 2, L. gorge, land	29	49.7	.....		45.8	.....		
Laguna Seca group								
Pan No. 3, Bailey ave., land	33	53.8	.....	56.6 in. = 100%	55.4	.....	56.9 in. = 100%	56.7 = 100%
Pan No. 4, L. S. north, land	31	62.3	= 100%		60.4	= 100%		
Pan No. 5, L. S. west, land	32	53.8	.....		54.8	.....		
Pan No. 6, L. S. west, floating	31	39.4	= 73.3	41.2 in. = 72.8	43.1	= 78.6	48.3 in. = 85.0	44.8 = 79.1
Pan No. 7, L. S. east, floating	31	43.0	..... = 69.0		53.5	..... = 88.6		
Upper Gorge group								
Pan No. 8, San Fel. dam., land	35	41.7	.....	45.1 in. = 100%	52.3	.....	51.0 in. = 100%	48.1
Pan No. 9, San Fel. res., land	7	47.2	.....		45.2	.....		51.0 = 100%
Pan No. 10, Up. Gorge, land	40	46.5	= 100%		55.4	= 100%		
Pan No. 11, Up. Gorge, floating	40	34.3	73.8	73.8 =	30.4	= 54.9	= 54.9	32.3 = 63.4
Mean of group means								
Land-pan evaporation				100%			100%	100%
Floating-pan evaporation				73.3			70%	71.3

sponding pan (a pan in same locality or under similar conditions);

B'' = Mean of daily rates observed for corresponding pan during periods just before and after the desired period, corresponding to a.

Then

$x'' : a''$ as $b'' : B''$ and $x'' \times B'' =$

$$a'' \times b'' \text{ or } x'' = \frac{a''}{B''} \times b''.$$

Example: Pan No. 1 (Weber Damsite Pan). Gap to be filled — Dec. 14-20, 1904. Compared with Pan No. 3 (Bailey Ave. Land Pan)

Pan No. 1

Daily rate Dec. 14-20 = x''
Daily rate Dec. 20-28 = $0.046''$
Daily rate Dec. 6-14 = $0.111''$
} mean = $0.079'' = a''$

Pan No. 3

Daily rate Dec. 14-20 = $0.02'' = b''$
Daily rate Dec. 20-28 = $0.044''$
Daily rate Dec. 6-14 = $0.046''$
} mean = $0.045'' = B''$

Then

$$x'' = \frac{0.079''}{0.045} \times 0.02'' \text{ or } 0.035''$$

TABLE VI. ADOPTED SAFE RESERVOIR-EVAPORATIONS, INCHES PER YEAR

Coyote Valley land pans	= say 54 in. per year
Coyote Valley reservoir evaporations	= say 80% of land pans = say 44 in. per year
Laguna Seca land pans	= say 64 in. per year
Laguna Seca reservoir evaporations	= say 80% of land pans = say 52 in. per year
Upper Gorge land pans	= say 56 in. per year
Upper Gorge reservoir evaporations	= say 80% of land pans = say 45 in. per year

The adopted reservoir evaporations were fixed on only after a careful individual comparison with all the Pan-Records and Group Records above. One %-relation of Table V (88.6%) is apparently somewhat disregarded, but it is believed that the adopted values are amply safe, especially that for the Upper Gorge Reservoir. It is believed that the adopted Upper Gorge evaporation, 45 in. per year, will be amply safe for all the streams of the Bay Cities Water Co., except Laguna Seca.

TABLE VII. ADOPTED RESERVOIR-EVAPORATIONS INCHES PER YEAR

Calendar year		Rainfall, year or season			
Month	Per cent.	Month	Per cent.	Laguna Seca, inches	Upper Gorge, inches
Jan	2	Sept	14	7.3	6.3
Feb	2	Oct	7	3.6	3.1
Mar	5	Nov	4	2.1	1.8
Apr	7	Dec	2	1.0	0.9
May	10	Jan	2	1.0	0.9
June	14	Feb	2	1.0	0.9
July	17	Mar	5	2.6	2.3
Aug	16	Apr	7	3.7	3.1
Sep	14	May	10	5.2	4.5
Oct	7	June	14	7.3	6.3
Nov	4	July	17	8.9	7.7
Dec	2	Aug	16	8.3	7.2
Total	100	Total	100	52.0	45.0

The monthly per cents. of Table VII are derived from means for each month of the means of group means. No adjustment is done except to bring each monthly per cent. to the nearest integral per cent. With but one or two exceptions, the values of Table IV of original plate (omitted here, gives monthly %-distribution for each pan) show a remarkable agreement with each other.

Method No. 2, for long periods and entire months.

This method consists mainly in establishing a mean per cent. relation between observed periods of the pan whose record is to be completed and corresponding periods of some near-by pan. Then the period lacking may be found by dividing its corresponding observation of the near-by pan by the per cent. relation established.

Example: Pan No. 6 (Floating Pan in Laguna Seca, west side). Periods lacking — months of January, February and March, 1904. Compared with Pan No. 3 (Bailey Ave. Land Pan).

1904	Pan no. 6	Pan no. 3
May	4.12 in. = 100%	7.27 in. = 176%
June	6.40 in. = 100%	8.07 in. = 126%
July	6.60 in. = 100%	9.23 in. = 140%
Aug.	5.71 in. = 100%	8.31 in. = 145%

Mean per cent. relation = 147%. Then Pan No. 3 evaporations ÷ 147% = Pan No. 6 evaporations.

1904	Pan no. 3	÷147% =	Pan no. 6
Jan.	1.463 in.	÷147% =	1.00 in.
Feb.	0.645 in.	÷147% =	0.44 in.
Mar.	2.207 in.	÷147% =	1.50 in.

New Tests on Reinforced-Concrete Columns at the University of Wisconsin

For the past few years tests on the strength of reinforced-concrete columns have been carried on in the testing laboratory of the University of Wisconsin under the direction of Prof. M. O. Withey. From time to time Professor Withey has reported upon these tests, in bulletins and in society papers (See ENGINEERING NEWS, Sept. 16, 1909, p. 300), but has not gathered together in one publication a resumé of the whole work. The nearest approach to such a resumé has just been published as a bulletin* of the University of Wisconsin. This takes up the work of the laboratory on reinforced-concrete columns during 1909 and 1911, and relates more specifically to the hooped column.

The matter contained in the bulletin is much too lengthy to bear more than the short abstract which appears below, though the whole record of the tests will be profitably read by everyone concerned with concrete design.

The purpose of the tests is stated as follows:

Briefly, the purpose of these experiments was to make a further study of the strength and elastic properties of columns reinforced with spirals and longitudinal rods. More specifically, the tests were made to obtain some data relating to (1) the effect of varying the percentage of spiral reinforcement; (2) the effect of varying the percentage of longitudinal reinforcement; (3) the effect of varying the richness of the mixture; (4) the effect of a small number of repeated loadings; (5) the effect of maintaining a constant load for different time intervals; (6) the behavior of columns eccentrically loaded; (7) the relative value of plain and deformed bars for longitudinal and reinforcement; (8) the effects of differences in end conditions. All told, 66 columns of commercial sizes were made and tested.

As a result of the tests, Professor Withey arrives at the following conclusions:

In considering the conclusions presented, it must be borne in mind that the specimens were very carefully made. Great care was taken in pouring to thoroughly puddle the concrete with a rod as fast as it was poured into the columns. It was by this means that pocketing of the stone was prevented and a full cross-section obtained throughout the length of the column. Puddling is a very effective method of securing uniformity in fabrication. When it is impossible to use this method the size of the largest particles composing the aggregate must be much smaller than the pitch of the spiral and a very wet mixture must be used. Assuming as hypotheses that a well balanced design will be made, that careful inspection will be given to the selection and testing of all materials and to the details of fabrication, it seems practicable to secure similar results in actual construction. The following general conclusions may be drawn from the results of these tests:

(1) If materials can be obtained at average unit prices, rich mixtures are more economical than lean ones. Considering materials similar to those employed herein, the more economical mixtures will be produced if the proportion of cement to aggregate, by weight, lies between 0.2 and 0.7.

(2) Although the yield point of a reinforced-concrete column is practically independent of the percentage of spiral reinforcement, the ultimate strength and the toughness are directly affected by it. On account of the excessive deformations accompanying loads beyond the yield point, on account of the probability that both yield point and ultimate strength are less in repeated or long time road tests than in the progressive load tests ordinarily made in the testing machine, and on account of the uncertainties which always surround the hypotheses adopted in designing, good practice demands that only a portion of the stress, producing disintegration of the outside shell, be used as a working stress. Consequently, only enough lateral reinforcement is needed to prevent the longitudinal rods from bulging outward, and to provide an additional factor of safety against an overload by increasing the toughness and raising the ultimate strength somewhat above the yield point. From these tests, 1% of a closely spaced spiral of high-carbon steel seems to be sufficient for this purpose.

(3) By the addition of longitudinal steel the yield point, ultimate strength and stiffness of a spirally reinforced-concrete column can be considerably increased. If maximum economy in floor space is desired, if a column is so long or is so eccentrically loaded that tension exists on a portion of the cross-section, or if a large dead load must be sustained by the column while the concrete is green, a high percentage of longitudinal reinforcement may often be advantageously employed. Such reinforcement is also a valuable safeguard against failure due to flaws in the concrete. If the cost of cement is extremely high, it may be economical to use a leaner mixture than suggested in (1) and considerable longitudinal steel to increase the stiffness and strength. In general, however, cement is a more economical reinforcement than steel. Therefore, for ordinary constructions it does not seem advantageous to use in combination with a rich concrete more than 2 or 3% of longitudinal steel.

(4) The amount of data presented on tests of columns subjected to repeated or time loadings is far too small to warrant drawing definite conclusions as to the limiting stress for repeated loadings which will hold true for all kinds of columns and for an infinite number of repetitions, or for a prolonged loading. However, it does appear from the results presented that there is practically no increase in set or deformation after a few r petitions of loads equal to 40 to 50% of the yield points of the columns tested. The results of the repeated load tests also plainly indicate that there is considerable additional strength and toughness afforded by the spiral after the yield point of the longitudinal steel has been passed. That all of this additional strength may not be permanent is suggested by the slopes of the deformation-time curves for some of the columns.

(5) The close agreement between theoretical values and values derived from test data shows that the formula

$$S = \frac{P}{A} \pm \frac{Mc}{I}$$

commonly used in designing short homogeneous columns eccentrically loaded, may be applied to reinforced-concrete columns, provided suitable allowance be made for the steel.

(6) The strength of a column resting upon a footing will be about as great as when bedded on a metal plate, provided considerable lengths of the longitudinal reinforcing bars are bent outward into the slab or footing. The results given show that the use of metal base plates and longitudinal steel milled to the required length leads to greater uniformity in strength.

(7) Although only a few test pieces were reinforced with corrugated bars of high-carbon steel, the results were so uniform and the strengths so high that attention should be called to this type of reinforcement. It is quite evident that, with certain ratios of unit prices, the use of deformed bars with high elastic limits will be more economical than the use of plain round bars of mild steel.

(8) Briefly summarizing the foregoing, it seems economical to use for reinforced-concrete columns a very rich mixture, and advantageous to employ about 1% of closely spaced high-carbon steel lateral reinforcement combined with 2 or 3% of longitudinal reinforcement. From the test data presented it seems apparent that such columns, centrally loaded, may be subjected to a static working stress equal to one-third of the stress at yield point.

Towing Three 600-cu.yd. Barges around Cape Horn is to be resorted to at the Panama Canal in order to get them from the Atlantic side of the canal to the Pacific side, a distance of 50 miles. The distance to be traveled is about 12,000 miles and the voyage will take 100 days.

*"Tests on Reinforced-Concrete Columns, Series of 1910," by Morton Owen Withey, C. E., Asst. Professor of Mechanics, University of Wisconsin. Bulletin of the University, No. 466. Published December, 1911. Price, 40c.

A Concrete Retaining Wall Failure

An illustration of the necessity of care in backfilling behind retaining walls. A massive concrete wall 400 ft. long and 40 ft. high was pushed over by the impact of the filling dropped some 30 or 40 ft. into place.

The theory of the pressure of earth behind retaining walls contains so many coefficients of widely varying value that engineers are apt to consider it only a rough check upon design, and use as their chief guide the proportions of similar walls which have stood up under service.

So long as there is reasonable assurance that the conditions are the same in the prototype wall as in the one under design, this practice is safe; but occasionally it leads to too much stress being put on the fact that the wall is a finished structure and not enough consideration being given to the effects of the various conditions incident to its erection. Particularly is this so in the matter of backfilling.

The theory of earth pressure considers the backfilling earth to be a homogeneous, granular, static mass, a condition which may possibly exist after the wall has been standing for some time, but which rarely exists immediately after its completion and never exists during construction. A completed wall is subject to a static load. A wall during construction, on the contrary, may be subjected to dynamic conditions in the placing of the backfilling. Ordinarily, in specifications for the construction of retaining walls, this possibility is covered by a specification clause stating that the earth backfill shall be placed in thin layers, carefully rolled and tamped and inclined downward from the structure and not thrown or dropped from any great height. Experienced engineers recognize the necessity for such a provision, but it sometimes happens that it is overlooked, with disastrous results.

For the benefit of those engineers who have either forgotten the powerful force which falling earth may exert or else do not consider such a force sufficient to cause any damage, we outline below the history of a concrete retaining wall which failed with disastrous results. The accident took place within the past six months, in the construction of a long bridge abutment on a prominent railway line.

The wall which failed was one of two abutments intended to carry a six-track railway bridge located on a pronounced skew across a navigation canal now under construction. The canal at this place is an open cut across a level plain and crosses under a railway line just before entering a lock which raises its level some 21 ft. The walls of the lock and of the railway-bridge abutment are continuous in line, though not in construction and are of different height. Both are founded on hard gravel slightly below the canal-bottom level, and extend up in a concrete gravity wall section to an elevation just above the general elevation of the surrounding plain. In constructing the wall an open cut was made through the plain with sides on a 1 to 1 slope and a bottom width equal to that of the canal plus the bottom width of the walls. The walls were then built directly upon the excavated bottom, and the back-fill from the excavated material was placed behind the walls to bring the level there back to its original elevation. In filling behind one of the abutment walls, the pressure of the earth became so great, due to certain circumstances detailed below, as to move and tip forward the entire wall for a length of about 400 ft.

Figs. 1 and 2 show the general design of the abutment. It was of gravity section stepped at the back and vertical on the canal side, with a ledge for the bridge seat about 8 ft. below the top. On account of the great skew, a length of 400 ft. was necessary for the six-track bridge. In this distance there were seven expansion joints, besides the one where the abutment joined the lock wall, divid-

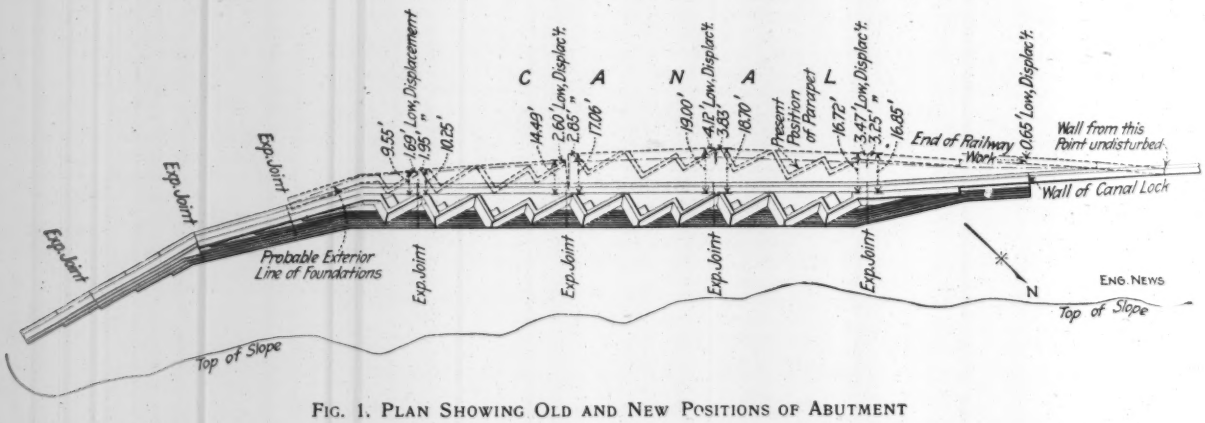


FIG. 1. PLAN SHOWING OLD AND NEW POSITIONS OF ABUTMENT

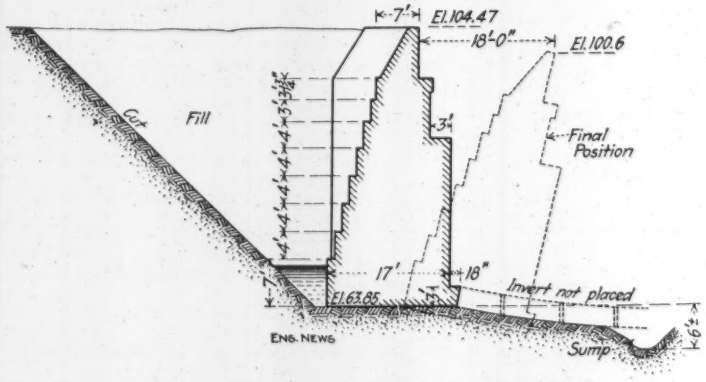


FIG. 2. SECTION OF ABUTMENT BEFORE AND AFTER MOVEMENT

ing the wall into lengths as near 50 ft. as the design permitted. At the bottom of the wall, there was a projection 3 ft. thick intended as the abutment for a 3-ft. invert, which was to have been placed across the canal bottom as shown in dotted lines in Fig. 2. At the time of the accident, however, this invert had not been placed between the abutment walls. The excavation for the invert had been made between the lock walls, and it was drained by an open ditch between the abutment walls.

This section of the canal was dug through a hard gravel and boulder formation, which resisted notably any efforts to drive piles. On this account and from other tests it was decided that the lock and abutment walls could be founded directly on the gravel bottom excavated for the canal. However, the location is in a valley where the ground-water level is quite high and where, consequently, the excavation pit soon became filled with water, requiring the constant service of a pump to drain it.

Work was started by excavating the canal in open cut for the length taken by the masonry structures. In other words, the excavation was an open pit in the flat plain. As soon as the excavation was completed, the work of building the concrete walls was started. These walls were built of first-class material by a competent contractor and no criticism is directed toward their integrity. The walls for the lock were completed first, and it was convenient to leave a sump at the other end—that is, the bridge end of the pit—to drain off the water from the lock end until the lock wall invert should be placed. This sump, as shown in Fig. 2, was dug to an elevation 6 ft. below the level of the finished invert between the abutments. In this sump a pump was placed which kept the pit fairly dry, though at times it was filled to a depth of 5 or 6 ft. with water. The concrete for the abutment walls was completed in about two months' time, and one week after the last concrete was placed, filling was started behind the east wall (the one which failed).

At the time this fill started, the wall was in the general condition noted in Fig. 2. The wall was founded on a hard gravel bottom, with a slight projection at its base on the inner side against which the concrete invert would abut when placed. Behind the concrete wall the earth stood on a 1 to 1 slope, and in the apex of the triangle between this slope and the wall, water, to a depth of approximately 5 ft., had been allowed to stand.

Filling was carried on by a drag scraper equipped with a 3½-cu.yd. bucket which moved back and forth from the top of the slope and dumped the earth which it picked up from a spoil bank made of material taken from the excavation. This scraper was so manipulated as to distribute the earth over an area of about 40 sq.ft. and to a depth of 2 ft. It was swung back and forth with each load so as to distribute it over this area as much as possible, but at all times the earth was dropped from heights of from 10 to 40 ft. This machine moved back and forth the whole length of the abutment about three times, so that at any one location about 12 ft. depth of fill was placed at a time.

FIG. 3. VIEW LOOKING FROM LOCK WALLS ALONG ABUTMENT WHICH WAS NOT MOVED. DAMAGED ABUTMENT ON LEFT-HAND SIDE OF CANAL

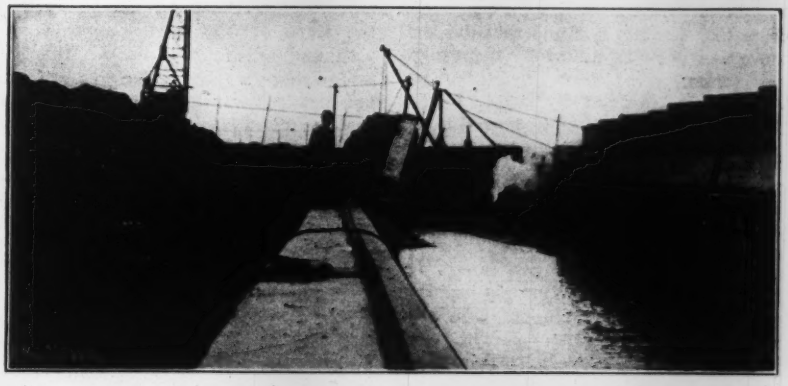


FIG. 4. LOOKING ALONG LOCK WALL TOWARD DAMAGED ABUTMENT
(Abutment originally in line with lock wall.)

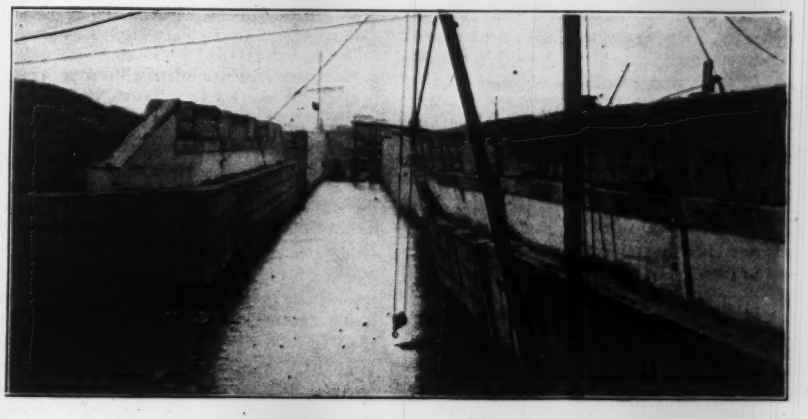


FIG. 5. LOOKING TOWARD LOCK. DAMAGED ABUTMENT ON RIGHT

In addition to the water behind the wall when the filling started there were at least two heavy rains during the filling period and in addition some of the earth was moistened artificially before being placed in the back-fill. In consequence, the fill for the lowest 10 ft. was at all times in a quaking state and in such condition as not to bear the weight of a man. Above this lowest layer the filling was

moist, but would permit at all times of a man walking upon it. About 14 days after the work started and when the fill was about half completed, a slight movement outward (about ¾ in.) was noted one morning at the exact place where filling had been carried on during the previous night. The inspector examined the wall, but decided that the movement was due to too great a concentration of the loading at one point and that no further difficulty would be encountered if the filling were more evenly distributed. This was done with no evil results until one afternoon about 10 days later the wall was found to be slowly moving along its whole length under the pressure in its rear. From 4 p.m. of that day to 8 p.m. it moved the distance shown in Fig. 2, that is, about 18 ft. maximum outward movement at the top with about 4 ft. drop. The position of the wall after the failure is shown in the halftone views in Fig. 4. It will be noted from Fig. 5 and from the drawing in Fig. 1 that the wall moved in units separated by the expansion joints.

Work was immediately started toward breaking up the wall with dynamite and building a new one of a section somewhat enlarged, not because the old section was thought weak in itself, but because it was desired to build the new walls of rubble concrete and use the broken pieces of the old structure for filling stones.

Examination after the accident showed that the wall had moved horizontally on its base until enough of it overhung the cut to overbalance it into the position which it finally took. The engineers decided that the design of the wall as a static structure was perfectly safe and that the gravel bottom was sufficiently hard to safely bear the wall as designed. The failure was undoubtedly due to the dynamic action of the falling earth together with the liquid state of the back fill at its base. This wet fill exerted over the whole back of the wall a hydrostatic pressure which gave a direct impact against the wall at the fall of each bucket of earth. This impact effect was increased by the unresisting nature of the slope of the earth back of the wall and of the wall itself. Into this wedge-shaped opening the falling earth pounded, causing not only an enormous force to be applied to the wall, but also tending to force the water in the voids of the wedge out under the wall, thus very effectively lubricating the bottom surface and reducing the frictional resistance of the wall to sliding.

This incident recalls a somewhat similar occurrence some five years ago in the construction of one of the largest concrete-arch bridges in this country. The back-filling against one of the abutments, a massive U-shaped structure about 56 ft. wide, 120 ft. long and 64 ft. high, was started before the arch against the abutment was completed. The fill was dropped from the extreme rear and allowed either to slide down the growing fill toward the face wall or to drop from the top level, some 50 or 60 ft., directly against that wall and its attached wing walls. In consequence, the face wall was subjected to an extreme pressure and parted from the wing walls, which in their turn were forced some inches out of plumb. The movement may have been partly due to the insufficiency of the footings, which were not designed to take the extreme load caused by the unbalanced fill, but was undoubtedly also hastened by the impact of the falling back-fill.

New Paving for Cambridge, Mass.

This article is based on a report by a special commission which reviewed the existing pavements of Cambridge, described kinds of pavement most suitable for future use and presented detailed estimates of the cost per square yard per year for the assumed life of each class of pavement. A paving schedule for a series of years was submitted. The necessity for continuous administration of paving work, free from political interference, was urged.

One of the most common causes for the deplorable condition of pavement in many American cities is the lack of a comprehensive plan for carrying out work from year to year. Even where such a plan is adopted it is likely not to be followed very long, owing to the frequent changes in administration which are the bane of American municipal government. Recognizing the desirability of having a comprehensive plan for paving, the City Council of Cambridge, Mass., in April, 1910, passed an order providing for the creation of a special commission to take up the subject. In accordance with the terms of the order, Lewis M. Hastings, city engineer, and Edward W. Quinn, superintendent of streets, became two of the four members of the commission; the mayor appointed George M. Clukas as the third member of the commission; and the Cambridge Taxpayers' Association, which had been authorized to name expert engineers to serve on the commission, suggested Harrison P. Eddy, consulting engineer of Boston, as the fourth member. In accordance with this decision, Mr. Eddy was appointed by the mayor. Subsequently Mr. Clukas was elected chairman and Mr. Eddy secretary of the commission. After having made interim recommendations, the commission submitted its final report on June 26, 1911, which has only recently been made public.

The report states that the area of Cambridge is approximately 6½ square miles, the census population in 1910 was 104,938, giving an average density of population of 25.1 per acre. Comparatively few cities of the country, the commission states, have an average density of population as great as Cambridge. Cambridge has greater length streets per unit of area than the City of Boston. The total valuation of Cambridge for taxation purposes is $170,000,000, or $1,044,000 per mile of public streets, the total mileage of streets being 102. These figures suggest that Cambridge should be "able to devote" more money to street-paving purposes than a number of other Massachusetts cities named in the report.

Complaints regarding the unsatisfactory conditions of streets in Cambridge relate particularly to dust, dirt and mud, noise and roughness of surface. To remedy these defects the commission suggests the selection of types of pavement adapted to traffic requirements and other conditions of the several streets; construction in the near future of a larger proportion of "durable pavement"; prompt repairs of defects in pavements; a strict supervision of trench openings in pavements; thorough street cleaning; and "the adoption and efficient execution of scientific methods of dust laying, or surface treatment of gravel, and macadam streets, due consideration being given to traffic and other conditions in each case." The following review of various classes of pavements suitable for use in Cambridge, with cost estimates per square yard of pavements per year based on the estimated life of the pavements, is taken from the report:

The cost of relaying granite-block paving, including a concrete base and recutting blocks, is estimated at $2 per sq.yd. If the blocks are recut and not more than 25% of the new blocks substituted for old ones, which are unfit for relaying, the cost of repaving is estimated to be $2.50 per sq.yd. The cost of renewing a grouted granite-block pavement at the end of its economic life, is estimated to be $2.50 per sq.yd. (large or small blocks).

BRICK—The brick pavements will consist of vitrified paving brick laid upon a portland-cement concrete base. The base will be 5 in. in thickness, and will be proportioned as described under granite-block paving. The bricks will be of the best grade, laid upon a sand cushion 1½ in. in thickness, thoroughly rolled or rammed. The joints will be filled with portland-cement grout, proportioned as described under granite-block pavement. Suitable expansion

joints will be provided adjacent to the curbs and transversely at intervals across the street. As in the case of granite-block paving, care must be exercised to prevent travel upon the finished street and to keep the pavement moist, especially in hot weather, until the cement filler has had an ample opportunity to set.

The vitrified brick pavement is smooth and durable. It is easily cleaned and not excessively noisy. It is a satisfactory pavement for residential and light business districts where the traffic is moderate, or where there is only a limited quantity of heavy traffic. The life of such a pavement as is herein described is estimated to be 15 years. The brick pavements already laid in Cambridge have been constructed in the manner recommended.

The estimated cost of brick pavement built as herein recommended is $3 per sq.yd., and the cost of renewal at the end of a period of 15 years is $2.10 per sq.yd. The estimated annual cost of this pavement is 24c. per sq.yd., as shown by the following calculation:

Assume period 40 years
" life of brick 15 years.
" life of base 40 years.
" term of bonds 10 years.
" first cost of pavement $3 per sq.yd.
" cost of renewing pavement, $2.10 per sq.yd.
" cost of ordinary repairs, 0.04c. per sq.yd. per year.

Interest first bond issue, 0.04 × 3.00 × 10 =	$1.2000
Sinking fund first bond issue (3½%), 0.08524 × 3.00 × 10 =	2.5572
Interest on second bond issue, 0.04 × 2.10 × 10 =	0.8400
Sinking fund second bond issue, 0.08524 × 2.10 × 10 =	1.7900
Interest on third bond issue, 0.04 × 2.10 × 10 × ⅞ =	0.5600
Sinking fund third bond issue, 0.08524 × 2.10 × 10 × ⅞ =	1.1933
Cost of ordinary repairs, 0.04 × 40 years =	1.6000
Cost for 40 years per sq.yd.	9.7405
Cost for one year per sq.yd.	0.2435

BITULITHIC—This pavement has been laid in Cambridge during every year since 1904, by the company having the patent rights, and was laid in Temple St., between Massachusetts Ave. and Austin St., in 1901.

It has consisted of a foundation, or base, composed of about 4 in. of broken stone, of a size which would pass a 2½-in. screen and a wearing surface 2 in. in thickness, composed of broken stone ranging in size from that just passing a 1½-in. screen to dust. This aggregate, while heated to a temperature of not over 250° F., was thoroughly mixed by machinery with bituminous cement, after which and at a temperature of not less than 200°F., it was to be spread upon the street and thoroughly rolled with a steam road roller. It was then covered with a thin coating of bituminous flush-coat composition. Two coats of fine hot crushed stone were then spread over the surface of the pavement.

In the future we would advise the use of a cement concrete base, usually 5 in. in thickness, in place of the broken-stone foundation previously used. Contracts for this pavement include a guaranty for a period of 5 years. This pavement has proved quite satisfactory in Cambridge. The repairs have been made with promptness and the pavements are at the present time in good condition. Several of them have been down seven or eight years and one—Temple St., laid in 1901—is now in satisfactory condition.

This paving is smooth, easily cleaned, and practically noiseless. It has proven to be well adapted for residental districts and for streets used largely for pleasure and high-speed driving, and under such conditions will, in our opinion, have a life of at least 10 years if the repairs are promptly made.

The first cost of this pavement, with concrete base and wearing surface 2 in. thick, is estimated at $2.65 per sq.yd., and the cost of renewal at the end of each period of 10 years at $1.50 per sq.yd. The annual cost of this pavement, assuming that it will be paid for by the issue of bonds for a period of 10 years in each case, is 28.4c. per sq.yd., as shown by the following calculation:

Assumed period 40 years.
" life of pavement 10 years.
" life of base 40 years.
" life of bonds 10 years at 4%.
" first cost of pavement $2.65 per sq.yd.
" cost of renewing pavement $1.50 per sq.yd.
Guaranty period of five years four times.

Interest first bond issue 0.04 × 2.65 × 10 =	$1.0600
Sinking fund first bond issue 0.08524 × 2.65 × 10 =	2.2588
Interest second, third and fourth bond issues 0.04 × 1.50 × 10 × 3 =	1.80000
Sinking fund second, third and fourth bond issue 0.08524 × 1.50 × 10 × 3 =	3.83580
Cost of ordinary repairs 0.12 × (4 × 5) 20 =	2.4000
Cost for 40 years per sq.yd.	$11.35466
Cost for one year per sq.yd.	0.284

WOOD BLOCK—The wood-block pavement should be laid upon a concrete base proportioned and made as already described. The blocks should be made from sound, prime long leaf, yellow pine, of which 90% shall be heart wood. They should be free from very coarse grain, large cross knots, unsound, loose or hollow knots, worm holes, knot holes, wind or other objectionable shakes and checks. They should be truly rectangular and uniform in shape, 4 in. deep, 4 in. wide and not less than 6 in. nor more than 10 in. long.

After being thoroughly sterilized by steam and the sap extracted, they must be impregnated with creosote oil of proper quality, at a rate of about 18 to 20 lb. of oil to 1 cu.ft. of wood. After treatment, when thoroughly dried, they shall not be capable of absorbing more than 4½% of their dry weight of water. The blocks should be laid loosely—not driven together—upon a sand cushion about 1 in. in thickness. After being so laid, they should be thoroughly rammed to a firm bed, after which the joints should be completely filled with portland-cement grout, mixed as already described. The surface of the pavement, after grouting, should be covered with a thin sprinkling of sand carefully swept into the joints. Traffic should not be allowed upon the finished pavement until the cement has had ample time to become thoroughly set.

This pavement is more nearly noiseless than any other pavement in use. On this account, it is particularly desirable in localities where it is important to avoid noise in the streets. As now prepared and laid, wood blocks have been used for street-paving purposes in this country only a comparatively few years, so that it is not possible to base any estimate of its probable life upon so prolonged an experience as is possible with most of the other pavements. It has been laid, however, in many cities and under various conditions, some of which are severe. Your Commission has examined this type of pavement in Springfield, New York, Philadelphia and elsewhere, and has made inquiries of large department stores, in front of which it has been laid. These inquiries, without exception, have resulted in favorable comments by the proprietors of these retail houses.

This pavement is smooth; there is little opportunity for the accumulation of dirt, and it can be easily cleaned. We believe that if constructed of the best materials and laid as herein specified upon the streets suggested, it will have a life of 15 years, and that it will prove an ideal pavement in these cases.

The estimated first cost of this pavement is $3.75 per sq.yd., and the cost of renewal $2.75 per sq.yd. The annual cost, assuming that the pavement will be paid for by the issue of bonds for a period of 10 years in each case is estimated at $2.92 per sq.yd., as shown by the following calculation:

Assumed period 40 years.
" life of blocks 15 years.
" life of base 40 years.
" first cost of pavement $3.75 per sq.yd.
" cost of renewing $2.75 per sq.yd.
Guarantee 5 years.
Life of bonds 10 years at 4%.

Interest first bond issue 0.04 × 3.75 × 10 =	$1.500
Sinking fund first bond issue 0.08524 × 3.75 × 10 =	3.1965
Interest on second bond issue 0.04 × 2.75 × 10 =	1.100
Sinking fund second bond issue 0.08524 × 2.75 × 10 =	2.3441
Interest on third bond issue 0.04 × 2.75 × 10 × ⅞ =	0.7333
Sinking fund third bond issue 0.08524 × 3.75 × 10 =	3.1965
Cost of ordinary repairs 0.05 × 25 =	1.250
Cost for 40 years per sq.yd.	$11.6866
Cost for one year per sq.yd.	0.292

TAR MACADAM—This is a term which is somewhat loosely applied to different combinations of bituminous materials, such as coal tar, and asphaltic oils mixed with or applied to cracked stone to produce a bituminous concrete, and it is now being used for building streets which are subject to traffic conditions which are moderate, but too severe for the ordinary macadam. The best combination of bituminous materials and the most effective method of construction of this type of pavement have not yet been fully determined. It is to be expected, however, that from the many experiments now being tried, a pavement will be evolved which will be well suited to streets subject to light traffic.

No recommendation is made at this time as to any particular method of construction of this pavement to be adopted, as we believe this can better be determined later, after further experience with the various materials and processes now being tried.

Pavements of this kind will be smooth and practically noiseless. They will be well suited to streets having very light traffic, and will be satisfactory in residential districts. The first cost of this pavement of entirely new construction is estimated at $1.25 per sq.yd., and the cost of renewal at 50c. per sq.yd. The annual cost of this pavement, assuming for comparison with cost of other pavements, that it will be paid for by the issue of bonds for terms of 10 years, and that interest at 4% will be paid on the cost of renewal for five years, is 29.6c. per sq.yd., as shown by the following calculation:

Assumed period 10 years.
" life of pavement 10 years.
" life of bonds 10 years at 4%.
" first cost of pavement $1.25 per sq.yd.
" cost of resurfacing pavement at end of 5 years, 50c. per sq.yd.

Interest first bond issue 0.04 × 1.25 × 10 =	$0.5000
Sinking fund first bond issue 0.08524 × 1.25 × 1.25 × 10 =	1.0655
Resurfacing cost 0.50 =	0.50
Resurfacing interest 0.04 × 0.50 × 5 =	0.10
Cost of ordinary repairs 0.10 × 8 =	0.8000
Cost for 10 years per sq.yd.	$2.9655
Cost for one year per sq.yd.	0.296

MACADAM—The use of macadam will be continued on many of the streets subject to light local traffic, for which it is both satisfactory and economical. If well constructed and properly maintained, it will have a life of at least 10 years and the cost of repairs will not be found to be excessive.

The annual cost of repairs after the year in which the street is constructed, and for a period of nine years, is estimated at 6c. per sq.yd. Where the construction is entirely new the streets will be built of trap rock of the usual sizes. The stone will be 8 in. thick after rolling.

A very large proportion of the streets are now macadamized, so that most of this type of construction will consist of resurfacing. In such cases the old stone will be picked up, covered with from 3 to 5 in. of new stone and thoroughly rolled.

The building of macadam streets involves the least first cost of any type of construction herein discussed, and is estimated at $1 per sq.yd. for new work. The annual cost of this pavement has been calculated for purposes of comparison upon the assumption that it will be paid for by the issue of bonds running for a term of 10 years, although the Act of 1910 prohibits the borrowing of money for such construction, and we do not recommend it. The estimated annual cost of this pavement, assuming that it will have a life of 10 years, and that it will be laid only in residential districts and upon streets subject to light and local traffic, is $0.179 per sq.yd., as shown by the following calculation:

Assumed period 10 years.	
" life of pavement 10 years.	
" life of bonds 10 years at 4%.	
" first cost of pavement $1 per sq.yd.	
Interest first bond issue 0.04 × 1.00 × 10 =	$0.4000
Sinking fund at 3½% interest, first bond issue 0.08524 × 1.00 × 10 =	0.8524
Cost of ordinary repairs 0.06 × 9 years	0.54
Cost for 10 years per sq.yd	$1.7924
Cost for one year	0.179

COMPARISON OF LIFE AND COST OF VARIOUS PAVEMENTS—A comparison of the estimated life and cost of various pavements in Cambridge under conditions best suited to each, may be made as follows:

Kind of pavement	Estimated life	First cost per sq.yd.	Annual cost per sq.yd.
*Macadam	10	$1.00	$0.179
*Granite blocks grouted with portland cement	20	3.25	0.2003
**Ditto	20	....	0.2366
*Brick grouted with portland cement	15	3.00	0.2435
*Bitulithic on concrete base	10	2.65	0.2840
*Wood blocks grouted with portland cement	15	3.75	0.2920
*Tar macadam	10	1.25	0.2960

Notes.

*Bonds to run for a term of 10 years. To make all calculations upon same basis, macadam and tar macadam are assumed to be paid for by issue of bonds for terms of 10 years. It is not advisable, however, to borrow money for such construction.

**Bonds to run for a term of 20 years.

In considering the annual cost of the several types of construction it should be remembered that the conditions in each case are different, so that it should not be assumed that any one pavement is necessarily cheaper than another because of the unit costs given. For example, the annual cost of macadam is given as 17.9c. per sq.yd., whereas that of granite-block pavement is 20.03c. But if the macadam were to be laid where the granite pavement will be, its life would be very much shorter than has been assumed in calculating its annual cost, and, therefore, its cost would be correspondingly increased; in fact, it would be increased so much that the macadam would be found to be far more expensive than the granite pavement. The figures given are interesting, although conceded to be approximate only, and they do show that some of the pavements which are high in first cost are not unreasonably so when due allowance is made for their wearing qualities.

A table is included in the report giving streets recommended for pavement from 1912 to 1921, inclusive, with the character of pavement and estimated cost of improvement for each street. The total for the 10 years' work amounts to about $1,000,000, the expenditure of which would be apportioned about equally between each of the 10 years. A similar table is presented giving recommendations for the renewal of existing granite, brick and Hassam pavements, from 1912 to 1921, at an average cost of about $45,000 per year.

BITULITHIC PAVEMENT—Another table gives a list of streets paved with bitulithic from 1901 to 1910, with description of the condition of pavement on each street with area of square yards and its cost. Of bitulithic on 17 streets, the present condition of 13 streets described is good and of the 4 as fair. The renewal cost of this bitulithic pavement is estimated as $2.05 per sq.yd., for a 2-in. wearing surface. The commissioners estimate that the life of bitulithic pavement is 10 years, but state "that its durability depends very largely upon the promptness and thoroughness with which repairs are made," the durability being more or less than 10 years accordingly. It is recommended that the pavement be "very carefully and promptly repaired whenever defects develop, and that when the expense of such repairs becomes excessive, the pavement be renewed." The total cost of renewing bitulithic pavement is $210,000 maximum, with the statement that it may be much less.

The total cost of the work recommended by the commission is $1,654,410. Of this $991,100 is for new construction, $453,300 is for renewing old granite, brick and Hassam pavements and $210,000 for renewing bitulithic pavement.

The necessity for continuous administration and for systematic records is urged. The remarks on this subject are well worth quoting:

It is of the utmost importance that this work be carried out from beginning to end with a single definite policy, and that the most approved methods be followed and the best quality of workmanship and materials be secured throughout. This cannot be secured by constantly changing administration, and for this reason the tenure of office of the officials in direct charge of this work should be made reasonably secure for a term of several years, and they should be free from political influences and interference.

We believe that the estimates submitted are ample to provide for carrying the work out in a reasonably efficient manner. Certain portions must be done by contract, other portions may be done by contract or by day labor, as may prove most economical. To determine the comparative cost of doing the work by day labor, or by contract, we recommend that bids be received for each piece of work undertaken, and that at the same time the Street Department present an estimate of the cost of doing the work by day labor. Such estimates should be prepared in advance, sealed and deposited in the proper place, and publicly opened and read in the same manner as the bids of contractors. In those cases where the department estimates are lower than the bids received, the work should be done by day labor, and whenever the tenders are lower than the estimates of the city, the work should generally be done by contract and efficiently inspected.

It is important that the cost of the work be accurately known, and be made a matter of record. It is desirable that the annual report of the street department should contain the bids and estimates made and the cost of the work, whether done by contract or by day labor. The prices should be given in units, such as cost per square yard, as well as in the aggregate.

The cost of regulating, repairing sidewalks and similar work not properly a part of the expense of the pavement itself, should be itemized separately, so as not to complicate the records of unit cost of pavements. All materials of value removed from a street to be paved should be credited to the work of paving the street from which they are taken, but such item should be kept separate and not included in the unit cost of the pavement, but should be reported with the cost of the work.

A Centrifugal Bore-Hole Pump installation is described briefly in a paper by Edward Hopkinson and Alan E. L. Chorlton, read before the Institution of Mechanical Engineers in January, 1912. The pump is arranged to work suspended in a bore-hole at a depth of 100 ft. below the surface. It has six chambers in series and is run at 1000 r.p.m. It has a capacity of 850 gal. per minute with a lift of 170 ft.

The pump is suspended in the bore-hole by a rising main, with its axis coinciding with that of the bore-hole, and is especially designed to fit the bore-hole lining tube (diameter not given). The pump and main are supported on a crutch pipe at the bottom. The pump is driven by a vertical shaft passing down the center of the rising main and supported at each pipe joint by suitable stay bearings. The shaft is belt driven through bevel gears by an engine at the surface.

The authors of the paper state that this pump has given continuous service for over 14 years, during which time it has received no repairs. It was brought to the surface only once during this period, when a portion of the shaft in the bore-hole was found to be corroded and required renewal.

Results of Tests on Three Rotary Air Compressors

Tests of rotary air compressors of the Rateau or turbine type, built by Pokorny & Wittekind Maschinenbau A.-G., of Frankfort-Bockenheim, Germany, were noted in London *Engineering* of Dec. 15, 1911. The first of these was built in 1909 for the Reden mines near Saarbrücken. It is driven at 4200 r.p.m. by a 1000-hp. mixed-pressure steam turbine. The tests were conducted by Prof. Lander, of the Aachen Technical High School. With 264,900 cu.ft. of free air compressed per hour from one to seven atmospheres (99.6 lb. absolute), the consumption of exhaust steam (taken at 15.6 lb. absolute and discharged at 1.14 lb.) was 7.98 lb. per 100 cu.ft. of free air and with this also was used 5.05 lb. of live steam (at 85 lb. absolute).

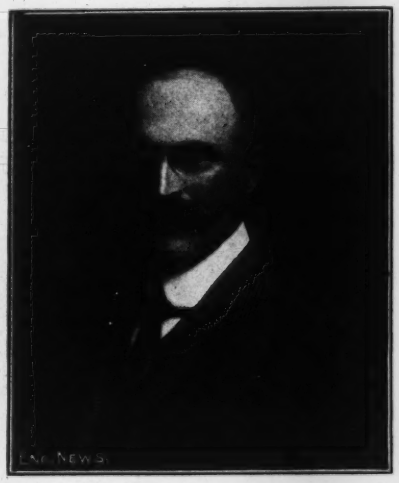
The second compressor was built for the Könnigsborn A.-G. für Bergbau, Salinen und Sodabetrieb, at Unna-Königsborn, Westphalia. It is driven by a 1000-hp. mixed-pressure turbine and has six wheels in the low-pressure group with seven in the high. There is an intercooler between stages, and between each impeller wheel is a water-cooled partition. Air is discharged at 60 to 70° C. Prof. Lander's tests showed that with 287,000 cu.ft. of air compressed per hour from atmospheric pressure up to about 114,000 lb. per sq.in. absolute, 7.74 lb. of exhaust steam (taken at 17.7 lb. absolute and discharged at 1.47 lb.) was required per 100 lb. of free air together with 4.54 lb. of live steam (at 103 lb. absolute). The isothermal efficiency of the compressor was from 64 to 65%. (The isothermal efficiency is the ratio of theoretical power required for isothermal compression to the actual power delivered to the compressor.)

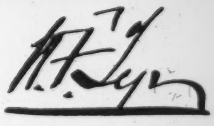
Tests were also made on one of six 4000-hp. motor-driven compressors of this type, built for the Rand mines in Johannesburg, South Africa. It had a capacity of 1,250,000 cu.ft. of free air per minute (from 11.8 lb. absolute to 128 lb., air being taken at about 20° C.). The compressor is in two sections, each shaft being driven by a 2000-hp. 3000-r.p.m. synchronous motor. The shafts are parallel and there are two low-pressure compressor sections on each shaft. One shaft also carries the intermediate stage and the other the high-pressure stage. When compressing 1,425,000 cu.ft. of free air per minute to 115 lb. absolute, the energy consumption per 100 cu.ft. of free air was 0.301 hp. The highest "isothermal efficiency" secured was 67.7%.

For comparison, figures from notes by Robert Peele, in his work on "Compressed Air Plant (second edition, 1910), may be cited. A two-stage 278-hp. Nordberg compressor of the Tennessee Copper Co., developed 0.247 hp. per 100 cu.ft. per hour and used 3.78 lb. of steam at 146 lb. gage. A 990-hp. Nordberg compressor at Painsville, Mich., in 1906, developed 0.223 hp. per 100 cu.ft. from 13.9 to 85.3 lb., and used 2.97 lb. of steam (at 256.8 lb. absolute) per 100 cu.ft. (See *Trans.* Am. Soc. M. E., Vol. 28.) It should be noted, however, that in the steam only 1157.46 B.t.u. per lb. was furnished the engine, on account of moisture, and that 305.14 B.t.u. were returned to the feed water directly by the engine. The "isothermal efficiency" was 82.8%.

William Francis Tye, President of the Canadian Society of Civil Engineers

The recently elected president of the Canadian Society of Civil Engineers, William Francis Tye, was born at Haysville, Ont., on Mar. 5, 1861. He was educated at Ottawa University and the School of Practical Science, Toronto, where he graduated at the age of 20 years.





The following year, 1882, he began engineering work as a rodman on construction of the Canadian Pacific Ry. During the three following years he was promoted successively to the positions of leveler, transitman on location and finally to that of assistant engineer on construction.

During the years 1886 and 1887 he was a transitman and assistant engineer on construction of the St. Paul, Minneapolis & Manitoba Ry. From Canadian railways Mr. Tye turned his attention to those of Mexico, and in 1888 served as Engineer of Track and Bridges on the Tampico branch of the Mexican Central Ry. Two years later he returned to the Northwest as Locating Engineer of the Great Falls & Canada Ry., a road built from Great Falls, Mont., to Lethbridge, Alberta, to open to American markets extensive coal deposits in Alberta. It is now a part of the Great Northern System.

From this position Mr. Tye succeeded to that of Engineer in Charge of Location and Division Engineer of the Pacific extension of the Great Northern Ry. The location of this railway through the main range of the Rocky Mountains was made with lower gradients than any other existing transcontinental line, the maximum grade east of the summit being but 1%, and west of the summit 1.8%.

The crossing of the Cascade Range was accomplished with a maximum grade of 2.2%, and on a route so direct that the distance from Spokane, Wash., to Puget Sound was shortened 94 miles over any other route. The location for most of the distance was through unexplored and mountainous country, and the work of construction was pushed in a manner which until that time was unequaled in railway building and track laying. The entire distance of 818 miles was completed in a little over two years from the time construction work was inaugurated.

Upon the completion of this work, Mr. Tye was for two years in charge of the work of changing the gage of the Alberta Ry. & Coal Co. lines to standard. In 1895 he was appointed Chief Engineer of the Kelso & Slocan Ry., and for four years following held a similar position with the Columbia & Western Ry., which was purchased in 1898 by the Canadian Pacific Ry. to form a part of its new line through the Crow's Nest Pass and the Kootenay district. The road was largely rebuilt by the new owners and changed from a 3-ft. to standard gage.

In 1900, Mr. Tye became Chief Engineer of Construction of the Canadian Pacific Ry.; in June, 1902, Assistant Chief Engineer of the entire Canadian Pacific System, and two years later its Chief Engineer. This was a period extendsive development and improvement in the lines of this company. In 1906, he resigned his position to enter private practice as a consulting engineer and to become a promoter of electric railway, power and mine developments.

Mr. Tye is now President of the Sterling Coal Co., Ltd., the Dominion Graphite Co., a director of the Home and Foreign Securities, Ltd., and a consulting engineer for numerous corporations. He makes his home in Toronto, Ont.

He is a member of the Institution of Civil Engineers, of Great Britain; of the American Society of Civil Engineers, and of the American Railway Engineering Association. He is also a member of the York Club, of Toronto; the St. James Club, Montreal, and the Manitoba Club, of Winnipeg.

Subway Equipment Improvements

The capacity of the New York City subway system has been increased from 400,000 to 1,000,000 passengers per day.

This increase has been necessary on account of a remarkable over-crowding of the system, and it has been secured by improvements in operating equipment and methods. Among the new and notable devices are the electro-pneumatic brake, the automatic car and air-line couplers, the automatic starting signals, and the speed-control track signals.

The overcrowding of the present subway system in New York is so widely known that extended discussion of it is trite. It is well to note, however, that the capacity of the present subway has been very greatly increased over the maximum provisions of the original design; otherwise the effects of the present overload of passengers in rush hours would have been intolerable. Without this increase in capacity, it is probable that some steps must have been taken to discourage travel at certain hours to prevent conditions of overcrowding in cars and stations which would have been absolutely intolerable.

In 1904 when the subway was opened, its capacity was placed at 400,000 passengers per day. In 1905, the first full year of operation, the daily average was 318,000. In 1906, before the Brooklyn extension was opened, the daily load was in excess of 400,000, and for 1910 the average figure was 740,000. For the month of November, 1911, the daily average was 968,000, so that it is now probable that a round million people ride in the subway on most week days.

This remarkable increase in capacity of some 150% has been secured by improvements in operating equipment and method and the intensive operation thus made possible. The platforms have been lengthened to permit of longer trains, and the interval between trains past a given point has been decreased. These two points, in brief, have given the increased capacity, but many notable improvements in equipment have been necessary before the longer trains and decreased headway were possible. The number and size of car doors have been increased; stations of greatest congestion have been provided with guide stanchions and special policemen to separate boarding and alighting passengers and preserve order; an automatic starting signal has been developed to eliminate the delay of passing the bell signal from rear to front end; the car-brake equipment has been improved to increase the rate of retardation and to decrease the safe interval between trains and the distance from a station at which brakes must be applied; the car coupler and air-brake hose connections have been combined in a new and stronger device which has practically prevented train breakages and has reduced the time of making up trains; speed-control track signals have been used at the approaches to express stations and junctions so that a motorman can approach close to a train standing at a station platform, provided he reduces his speed in a predetermined safe manner.

With the subway traffic so dense and such small time intervals between trains, the effect on the whole system of appreciable delay at one point is and must be marked. That is, the increase in the capacity has been secured only by greatly decreasing the flexibility of operation. This is, of course, a matter beyond the control of the operating company.

In addition to equipment changes giving increased capacity, several have been made to increase the safety or comfort of passengers. Among these should be noted the anti-climbing platform ends, the metal handles replacing hand straps for standing passengers, the ceiling fans, tungsten lamps, etc. Some of these interesting developments are described later.

In putting into effect these betterments, the executive officers of the company, it is stated, have given the operating and equipment officials a free hand and orders to proceed on every promising line without regard to the expense involved. In the course of this betterment work some $8,000,000 has been expended, which is about half the annual gross return.

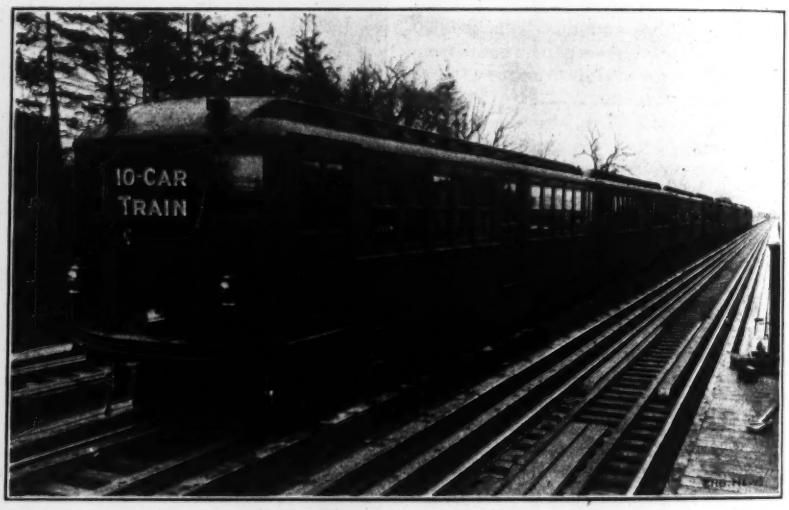


FIG. 1. TEN-CAR SUBWAY TRAIN; INTERBOROUGH RAPID TRANSIT CO., NEW YORK CITY

ELECTRO-PNEUMATIC BRAKE

With the old form of brake equipment, the application of the braking force to the wheels of the several cars of a train, by pneumatic release, was a serial function traveling back rapidly, but not "instantaneously," through the length of the train. When trains as long as 10 cars began to be operated, a considerable time interval, often as much as four seconds, was found before complete response to the motorman's action was secured. This lengthened the time required to bring a train to stop and occasionally introduced a peculiar and serious delay. Suppose, for instance, on approaching the signal at "danger" the motorman applies brakes, but almost immediately the signal clears so that he throws his brake handle to the release position and applies current with his controller. There is no time lag in the operation of the motors, so that the motorman's operations result in having the brakes set on the rear cars, while released on the forward cars and with power applied to the motors on all cars. The resultant tendency is for the forward cars to jump ahead and away from the rear cars. Thus it is possible to break the trains apart with consequent delay and disturbance to schedule all along the line. With trains at an interval of 1 min. 40 sec., it is seen that a comparatively short stoppage of traffic due to the breaking apart of the train at one end of the line would shortly tie up traffic to the far end of the line.

The company began trials of the Westinghouse electro-pneumatic brake system, in which the function of the triple valve of the old equipment was supplemented by admission and release magnets under the control of the motorman. In this way the brake cylinders on each and every car of the train were charged or vented simultaneously. In the opinion of the Interborough engineers, the design of this system as developed for other service was not adequate for the subway conditions and certain additions were made at the suggestion of the Interborough company.

One of these was to avoid loss of control of the braking function when the line current went off. In the first design there was no indication to the motorman when the line voltage was lost, if he had already shut off power and happened to be coasting, unless he observed the lights of the car. As a result, the motorman might attempt to apply the electric brakes on approaching a danger signal or the rear of a preceding train. He would not realize that he could not apply the brakes until it was too late and he was close upon the signal or the train. This might tend to further confuse him when it was necessary to use the straight pneumatic control of the brakes. This trouble has been obviated by putting a release valve on the train air line, held closed by the current and allowed to open on the failure of the energy supply. Whenever the current goes off, the brakes are applied automatically by the action of the triple valve and a pneumatic warning is sounded in the motorman's cab. The first design, too, retained the old automatic stop features; that is, a straight pneumatic application, worked by the track stop, etc., which led to the old serial functions and introduced the old-time lag into emergency stops. This has been necessarily supplemented by an electric emergency device operated by sudden release of brake-pipe pressure at any point, giving instantaneous application on all cars.

The system as finally perfected is a quick-action, quick-recharge, pneumatic system with a 30% increase of emergency shoe pressure over working value, supplemented with electric valves to admit pressure to or release it from the brake cylinders without movement of the triple valve and with simultaneous electric operation of all the triple valves for emergency stops. On motor cars, a 14-in. brake cylinder has replaced the old 12-in. to secure the greater braking force. The 12-in. cylinder is retained on trailers, however.

Fig. 2 shows the arrangement of parts somewhat simplified. The upper portion of the motorman's brake valve, Fig. 6, contains a miniature electric controller making proper contacts for the electric-control features. The pneumatic portion is much like the older pneumatic valve in operation, except that full pneumatic release is removed; the motorman cannot make full connection from reservoir line to brake pipe or overcharge the latter. A feed valve in the base of this brake valve maintains the brake-pipe pressure at 70 lb. when the brakes are not set.

The old quick action of the triple valve (a moderate local reduction in the pressure of the brake pipe at each triple valve, which communicates rapidly the length of the train the effect of a quick reduction in pressure at the motorman's brake valve) while still preserved in a modified form for straight pneumatic operation, is supplanted by the quicker (simultaneous) action of electro-magnets thrown into circuit throughout the length of train by the electric part of the motorman's brake valve or by a vent-valve switch operated by a sudden reduction of brake-pipe pressure due to the automatic trips, conductor's valve or broken train connection.

With the pneumatic apparatus in normal (running) position, the electric service control is by means of the brake-valve controller, the four car wires and the release and application magnets with their poppet valves which govern the flow of air directly into and out of the brake cylinder. In making an application of the brakes (see Fig. 2), the first step of the brake-valve controller sends current through the release magnet (Fig. 5) to close the free exhaust of the triple valve (and brake cylinder) from the atmosphere, the triple valve being at release position; the second step holds current on the release magnet, but also sends current to the application magnet (Fig. 5) to open the application relay-valve and send air from the auxiliary tank to the brake cylinder without action of the triple valve.

This relay valve is introduced to eliminate the very powerful magnet which would be needed to move a valve large enough to supply air to the cylinders at sufficiently rapid rate for the service application. The relay valve works against a spring to cut off the auxiliary tank when the brake-cylinder pressure

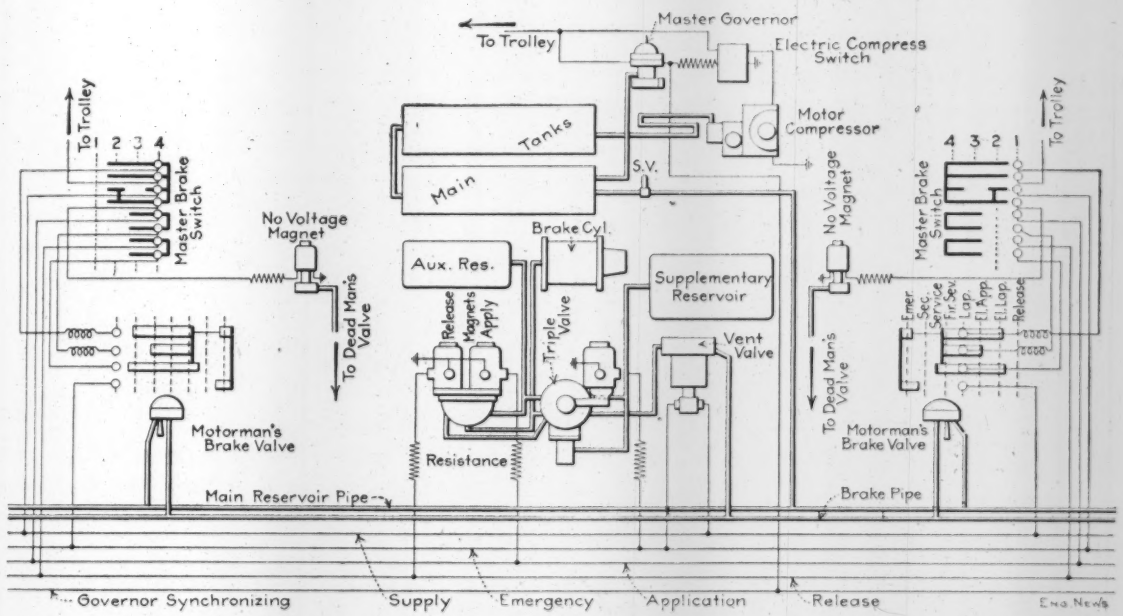


FIG. 2. ARRANGEMENT OF WESTINGHOUSE ELECTRO-PNEUMATIC BRAKE SYSTEM ON NEW YORK SUBWAY CARS

has reached 20 lb. below normal brake-pipe pressure (70 lb.).

Holding the motorman's brake valve in the third position will maintain cylinder pressure; in moving back to the electric lap the air supply is shut off. Should the motorman turn back to release position, the exhaust of the cylinder to atmosphere would be opened and the brake-cylinder pressure would be reduced. The motorman can hold his valve at this position for full release or he can throw it ahead to the electric lap, cutting off the exhaust and holding whatever reduced brake pessure is desired. In this way the brakes can be applied or eased off in any desired gradation.

All during the manipulation of the electric-control apparatus, the feed valve in the base of the motorman's brake valve is feeding air to the brake pipe, maintaining its pressure and consequently recharging the auxiliary and supplementary reservoir through the triple-valve charge in the cylinder. An extra finger is added to the brake-valve controller coming into use at the old pneumatic emergency position. When the controller is moved this far, the emergency finger sends current along the special train wire (marked "emergency," Fig. 2) to which the emergency magnet on the triple valve (Fig. 4) is connected.

To secure simultaneous emergency applications throughout the train, in case of operation of a track trip, conductor's valve or a broken train connection, a "vent valve" (Fig. 3) is provided and equipped with electric contacts to serve the purpose of the emergency finger of the motorman's brake valve, closing the emergency circuit whenever the brake-pipe pressure is suddenly reduced. This device contains a duplex piston and cylinder with a small reservoir and chamber connected to the brake pipe so proportioned that the pressure in the reservoir will fall with that in the brake pipe, so long as the rate of fall in the latter does not exceed that with a service application of the brakes. When the reduction of brake-pipe pressure, however, is greater, the difference in pressure on the two sides of the piston causes it to move and to open direct communication between the brake pipe and the atmosphere. A contact attached to the vent-valve piston closes the circuit between the supply and emergency wires. This not only actuates the emergency magnets on all the triple valves of the train, but is in itself an improvement for straight pneumatic control in that the service and emergency operations are not combined in the triple valve, where it is difficult completely to prevent undesired emergency operation with both service and emergency actions dependent on one piston and slide valve.

One feature of the older equipment has been eliminated—the venting of brake pipe to brake cylinders directly. But in place of this, the supplementary reservoir, provided to make the emergency application more powerful than the service, is vented directly to the brake cylinder in emergency operation.

The brake handle can be removed from an idle brake valve (at the end of a motor car to be made up in a train) only in the pneumatic lap position, which is an electric application position. It is necessary, therefore, to disconnect the electric part of the idle brake valves from the train brake-control wires. This is done by the master-brake switch shown in Figs. 2 and 7. This master switch has a handle which can be removed at the "off" position only. When this switch is at "off," the no-voltage magnet would release the emergency ("dead man's") air valve on the controller, but this action is prevented by a rotary valve operated with the master-switch spindle. In the second position, the master switch merely energizes the no-voltage release magnet and opens the rotary valve. The third position removes voltage from the supply wire and kills the automatic electric emergency applications (the pneumatic emergency being in service).

The brake-control train wires are carried in separate conduit, with an independent car jumper to minimize trouble. In the remote case of trouble with the supply line or electric emergency features the motorman may run with the master brake switch in the third position, giving electric service application and pneumatic emergency. In the case of still worse trouble with the train wire or service magnets, the master switch may be put to the "off" point and the train run on straight pneumatic control. With loss of line voltage when the motorman desires to coast down grade without waiting for electric recovery of the no-voltage valve, he can throw off his master switch and release pneumatically.

It is seen that electric operation secures the initial pressure at the rear of the train quicker than with the older

FIG. 3. VENT VALVE

FIG. 4. TRIPLE VALVE AND EMERGENCY MAGNET

FIG. 5. RELAY VALVE WITH RELEASE AND APPLICATION MAGNETS

FIG. 6. MOTORMAN'S VALVE AND BRAKE CONTROLLER

FIGS. 3 TO 6. VALVES OF PNEUMATIC BRAKE SYSTEM

pneumatic control and also increases the pressure more rapidly. Increase in rate of pressure was not desirable with the older pneumatic control since shocks, uneven braking and skidding of wheels would result with time lag of brakes at the rear and difference in the retardation at different parts of the train.

Retardation tests have been made at 40 miles per hour with a 10-car train with the electric-pneumatic brakes, and with an eight-car train having the older style quick-action pneumatic control. In Fig. 8, Curves I and II show that the 10-car train has stopped in 20 seconds, while the eight-car train is still traveling at 25 miles per hour, or 62.5% of initial speed, and with 39% the kinetic energy it had at 40 miles per hour, Curves III and IV show the differences in applied braking force; with the electro-pneumatic apparatus, the graduated release, noted above, was used to prevent excessive retardation toward the end of the stop. This was attempted on the older style equipment by releasing and reapplying. These curves show that the power may be shut off sooner with the new equipment and a drifting period, longer by 11 seconds, allowed to secure a considerable saving in power consumption. It also allows the alternative of higher average speed between stops, which may tend to offset station delays or permit the operation of more trains.

In Fig. 9, curves for comparative emergency stops of the same eight- and 10-car trains are given. The train with electro-pneumatic brakes was stopped in 350-ft., or two-thirds its length, at which distance the eight-car train had still a speed of 28.3 miles per hour and 50% of its original kinetic energy. Moreover, the eight-car train reached the 350-ft. point four seconds before the 10-car stopped there. When the electro-pneumatic brakes had brought the 10-car train to a standstill, the other train had gone 140 ft. further and was still moving at 20.2 miles per hour and had 25.5% of its original kinetic energy. When the final stop of the latter train was made, it was at a point 300 ft. farther along than the 10-car.

The Combined Car and Air-line Couplers

The couplers formerly used on the subway cars were simple radial bars with smooth buffing faces and connected by links and pins. There is a great deal of lost motion in such an arrangement which may be desirable for train-and-

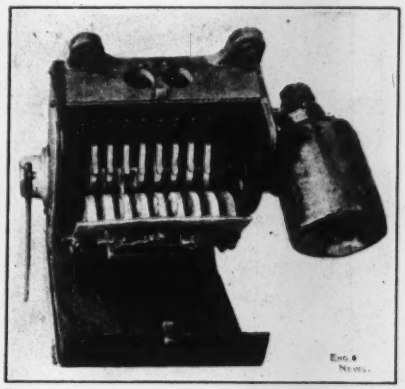


Fig. 7. Master Brake Switch; Electro-Pneumatic System

locomotive operation when one car after another is to be started along the length of the train. However, when the train is composed entirely of motor cars, or when every other car carries motors, the requirements are different. Each motor car starts at the same instant, and there is a great deal of crowding and pulling especially upon the trailer cars, and this leads to bumping and rough acceleration.

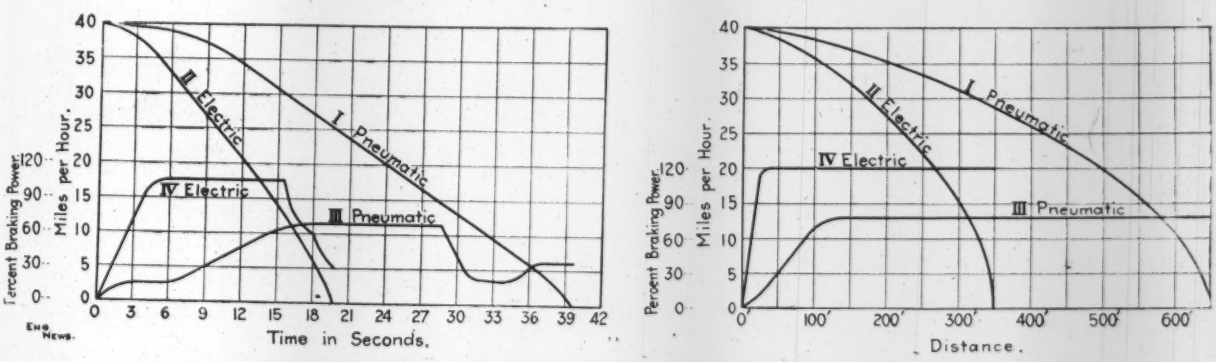
If the coupler faces were longitudinally rigid, these shocks would be absorbed in the draft gear of the coupler. It was recognized also that if the engaging faces of the couplers were locked against both vertical and longitudinal, relative movement, the air hose could be done away with, the train air-line connections being automatically established at the coupler faces.

The M. C. B. standard-type of coupler in use on American steam roads was not found suitable, as a small longitudinal play between faces, increasing with age, was permissible and horizontal alignment was not required. The most promising device found by the Interborough engineers was an invention of Geo. Westinghouse some 10 years old. This was developed largely for European fields, where M. C. B. standards were not enforced. It was used to a limited extent also on a few Connecticut interurban lines. The invention seemed ahead of its time, however, and was laid aside by the inventor with the belief that the demand for it would eventually arise.

The general appearance of the coupler and draft gear, not attached, is shown in Figs. 10 and 11, and by Figs. 12 and 13 in place on a car. The coupler has a long swing about the end of a radial shank in addition to limited vertical movement about a horizontal hinge at the back of the head casting. A lug on the bottom of the latter engages with a spring and plunger which tends to keep the head up. The radius bar is pivoted on the center sill and supported at its front end by a lip on the draft-gear box which engages with a flat carrying ring under the body end (see Figs. 11, 12 and 13). At curves and grade changes, the movement of cars is accommodated by the hinges and pivots, the faces remaining rigidly locked.

In the box back of the coupler hinges (Figs. 10 and 11) is a Forsyth spring and friction draft gear. This is made up of four sets of flat steel plates made to act as leaf springs by curved end and intermediate plates.

The head is a solid casting with a hook end and recess engaging with the head of another coupler as shown in Fig. 14. The head faces are designed so that the draw-bar ends will gather and couple when 7 in. off center, horizontally and 3 in. vertically. From the air pipes on the draw-bar shank (see Figs. 12 and 13) short hose connections are made to the coupler head and to the car pipes to



Figs. 8 and 9. Braking Tests of Trains with Quick-Air and Electro-Pneumatic Brakes

accommodate motion about the hinges and back pivot.

To couple or uncouple, the hooked ends of the two ends slide into or out of each other about 1½ in. at an angle of 40° with the draw-bar axis. This motion is prevented after coupling by a lock bar which, however, may be released by a cam and handie as seen from Figs. 10, 11 and 14.

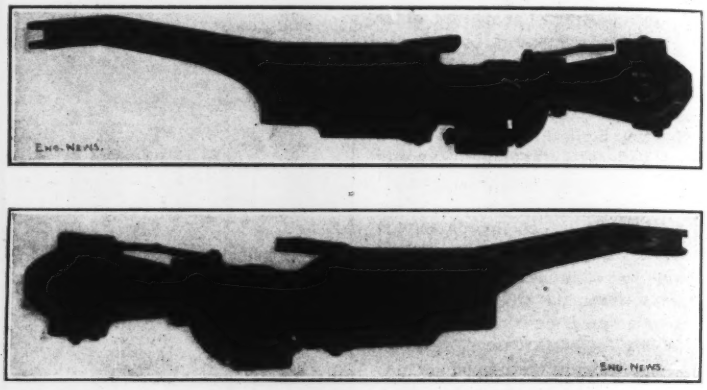
Some 1600 of these couplers have been placed on subway cars with what is called "100% efficiency of operation."

The electro-pneumatic brake jumper box is carried by a bracket from the coupler together with the door-signal jumper head. This point of support of the jumper box, rather than at the side of the car ends, makes necessary only half as many boxes for all coupling positions and enables use of shorter cables. The main voltage-bus wire and the multiple-unit motor-control train wires are still carried from car to car by jumpers at the sides of the car ends.

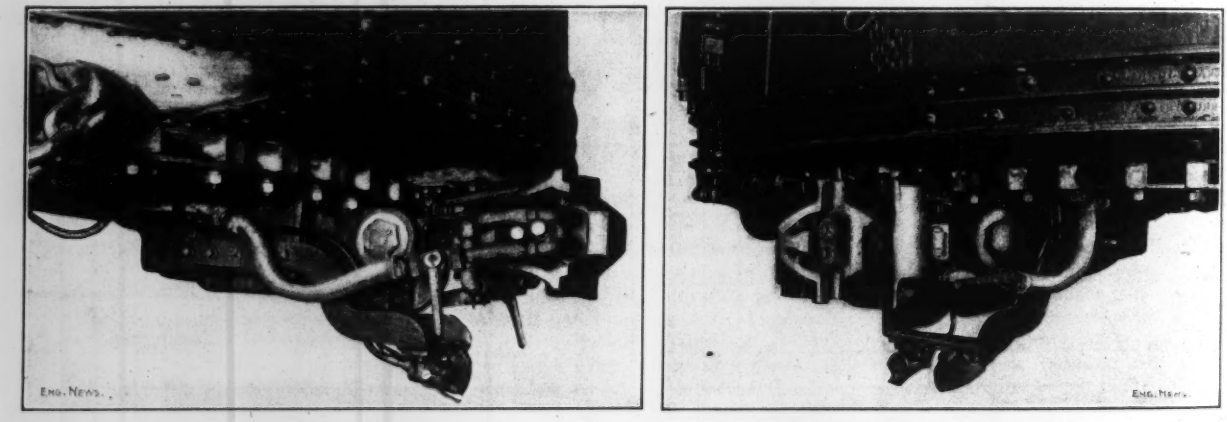
Automatic Car-door Signal

In addition to the car equipment which has resulted in the gain of a few seconds in the station waits is the flash-light signal which shows the motorman when all the train doors are shut. This scheme is shown diagrammatically in Fig. 15; a series circuit is carried through the length of the train with the current supplied from the last car and the indicating lamp in the motorman's cab. This lamp is in a small iron case with peek holes; a duplicate lamp is carried in the same case with an automatic switch to cut it in should the first lamp be burned out. The opening of each door introduces a break in the series circuit which can then be completed when all doors but one are shut. This one door is back in the motorman's cab and the use of the four-point switch shown enables this door contact to be included or excluded according as the front end of a car is or is not the front end of the train.

The scheme is simple enough, but no little trouble has been found in the past with contact devices to be used on the car doors, particularly in possibility of giving a "closed" signal before the door was quite shut, as would be the case when a passenger's hand might be between the door and casing. The device used by the Interborough company is simple but effective and accurate, it is reported. To the rear of the door, near the bottom, is attached a hard-wood pole bearing near its outer end a heavy brass sleeve. The end of this comes in contact with two metal fingers when the door is shut within, say, half an inch, so that any small obstruction prevents giving the proceed signal to the motorman. This pole and contact device are under the longitudinal seats shown in Fig. 16.



Figs. 10 and 11. Westinghouse Car and Air-Line Couplers; With Forsyth Draft Gear



Figs. 12 and 13. Westinghouse Car and Air-Line Coupler in Place on New York Subway Car

Side Doors

In considering the introduction of side doors into the subway cars, it must be borne in mind that the design of the cars as originally constructed provided for carrying practically all of the weight of car body and passenger load on the side framing which acted as a plate girder, this design having been found to combine most economically the desired qualities of strength and minimum weight. The center sills were necessarily made shallow in section on account of the exceedingly limited clearances over the motors, and were therefore used simply to resist buffing shocks, and to transmit their portion of the dead load to the cross stringers. The introduction of center side doors, of course, destroyed the original side girders and recourse was had to a "fish-belly" plate girder dipping under the doorway, and spliced to the remaining parts of the original side girder on either side. The increase in weight to be carried, due to center-door material, added equipment, and passenger load, necessitated a very substantial construction of these girders and a further reinforcement of the bolsters, side posts and bulkheads on some types of cars.

A peculiar feature of the attempt to shorten station stops by acceleration of passenger movement in and out of cars through the introduction of center side doors was found; no matter how wide the doorway was made, under conditions of maximum congestion at points other than

terminals, those passengers not desiring to get out at the particular stop in question would congregate in the doorway and move aside only just enough to permit a single file of people to enter or depart. A partition, or barrier, was therefore placed in the center of the doorway, and it has proved to be successful in establishing a double-file flow of passengers.

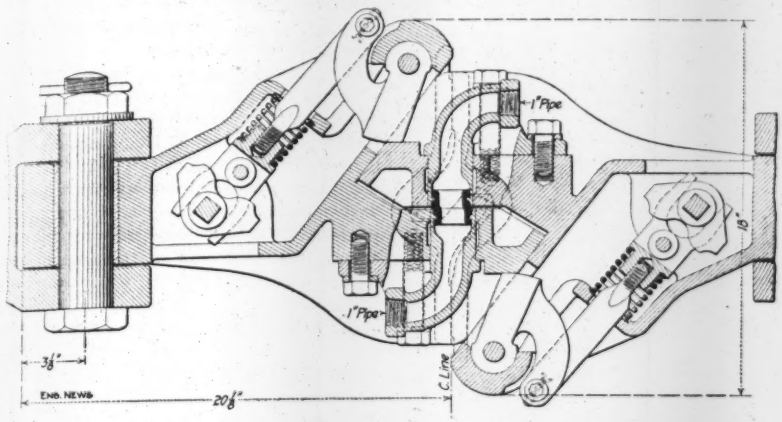


FIG. 14. SECTIONAL PLAN OF WESTINGHOUSE CAR AND AIR-LINE COUPLER

DOOR-OPERATING DEVICES

In order to permit the center side doors to be operated by the train guard standing on the car platform, pneumatic engines were provided, the control of the admission of the air to the cylinders being through valves located on the engines which are operated by means of a system of rods and levers leading to the car platforms. These engines consist of short cylinders, the pistons of which have a travel of about 12 in. The stem of the piston is formed into a rack which meshes with a gear bearing a long lever, the outer end of which is connected to a crosshead working in a slide fastened to the rear edge of the door. At all of the most crowded passenger stations, uniformed guards are stationed on the platforms to assist in expediting passenger movement. It was therefore desired that these station guards should be able to close the center doors without the aid of the train guard. To this end the operating mechanism is arranged so that when the door is fully opened the door lever becomes disconnected from the engine gear and rack so that the door can be closed by hand to a point near the closed position. Then an auxiliary lever is engaged opening the valve and admitting air into the cylinder so that the piston and rack follow after the door until in the proper position for reopening the door when required.

It was found that, even with greatest care exercised by the train guard, occasionally a passenger would be caught by the door in closing. To eliminate this danger, the supply of air is automatically shut off when the door in closing strikes any obstacle. The device for this consists of a light steel shoe slipped over the front edge of the door and held in position by a long and flexible coil spring. When this shoe strikes an obstacle it collapses over the door edge and by this motion operates bell cranks, and rods, and a valve on the door engine to exhaust air from the engine cylinder. When the obstacle is removed the coil spring pushes the door shoe back to its original position; the valve is thereby closed, air is again admitted to the cylinder, and the door moves ahead. This device is reported very successful in reducing the number of serious injuries to passengers.

SANITARY STRAPS, FANS, LAMPS, ETC.

It is generally conceded that it is seldom feasible to provide a seat for every passenger of an electric-railway line during the morning and evening rush hours, and the ceiling strap has become a regular equipment of cars of all sorts as the best comfort the company could provide during short overloads. The leather strap is rather unsanitary even when regularly cleaned, as in the New York subway cars, with antiseptic compounds. As a further improvement, a metal handhold has been devised which has proved clean and convenient. This is shown in Fig. 16; a piece of white-enameled steel tubing, bent like a strap in the passenger's hand, is fastened to a casting which revolves about a horizontal bar. The motion is opposed by springs and the travel is limited to some 50° each side of the position shown. This seems even better than the arrangement seen elsewhere, of iron stanchions and cross bars coated with hard white enamel, since only the uprights are particularly convenient, the cross bars being necessarily rather high.

As the number of trains operated and their loads have been increased, the amount of electrical energy required, and eventually all converted to heat, has greatly increased with corresponding rise in the temperature of the subway air. The ventilation possibilities of the subway as constructed are not great and the temperature is bound to rise in summer to one of extreme discomfort—a fact, however, for which the operating company is not responsible.

The company, therefore, has installed a special design of ceiling fan—four to a car on all the express trains. These force the air from the ceiling down against the passengers, diffusing it out at an angle of some 60° with the vertical. The air is forced out around doors, etc., and its place is taken by air coming in the monitor ventilators.

At first thought, the utility of this installation, expensive to install and appreciably adding to the peak-load current, was questionable, since only warm air could be circulated. However, it is seen that the air being warmer than that outdoors, is less nearly saturated and capable of absorbing more moisture. With the circulation induced by these fans, evaporation from the skin has been promoted with local temperature reduction.

The fans were designed by the General Electric Co. as series motors, with special features for reduced maintenance care and safety to passengers. The blades are of aluminum, riveted to a spider securely fastened to the armature shaft. The armature cannot be removed from the field-frame casing until the motor is taken from the ceiling, so that there is no danger of its dropping on the passengers as the result of a broken bearing, etc.

Express-service cars have been equipped with the new drawn-wire tungsten-filament lamps, giving a very desirable illumination with a satisfactory life of the lamps.

The "anti-climber" platform ends, which were invented by Frank Hedley, vice-president and general manager of the Interborough company, some three years ago, have proved highly desirable in locking the car platforms together in cases of collision, to prevent telescoping, and their use has rapidly extended to other electric-railway lines about the country. The first anti-climbers used in the subway were attached to the platform ends, but the construction of new steel cars has enabled the device to

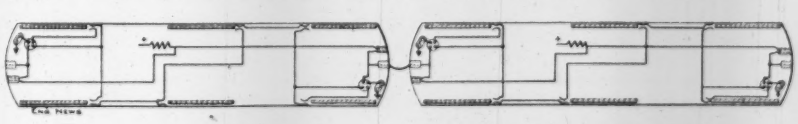


FIG. 15. DIAGRAM OF CAR-DOOR SIGNAL CIRCUITS

be incorporated as an integral part of the platform, as shown in Fig. 17.

Speed-control Block Signals

Speed-control block signals were devised in 1908 by J. M. Waldron, signal engineer of the Interborough company, for the double-track junction of the Broadway and Lenox Ave. lines at 96th St., where traffic was being throttled. They have been patented and extended with great success to the approaches of all express stations. By these, a motorman is permitted to approach close to a junction or a train standing at a platform, provided that this approaching train reduces its speed in all cases so that there is a safe braking distance between the train and junction or between the two trains for the speed preserved.

Fig. 16. Interior of Steel Motor Car; Interborough Rapid Transit Co.

Formerly without these signals, the approaching train was held up at the full distance required for safe braking distance of full speed and several seconds were lost in gathering headway and approaching a station or junction—time which was added to the minimum delay for loading at the platforms, decreasing the number of trains that could be operated in a given time. A headway of less than two minutes was not possible.

In considering the development of these special signals and their inter-relation with the other signal equipment of the subway system, it should be borne in mind that the block signals are automatic and the interlocking signals semi-automatic. Automatic track trips operate with these signals to apply the brakes on a train should a "stop" indication be disregarded, and "overlaps" are needed in the track circuits and signal spacings, the length of overlap in front of the home signal being equal to the braking distance of a train tripped at full speed. Thus in Fig. 18, signal No. 2 may be spoken of as a "home" with the "distant" indication of its position given on a signal beyond the limits (at the left) of the diagram, and with an overlap represented by the distance to Signal 6.

The propulsion current is carried on one rail which is continuously bonded. The track circuit for signals consists of both rails, one of which (the one not carrying propulsion current) is broken up into sections by insulating joints. The track blocks are fed with alternating current from small transformers and relays are connected across the rails, being normally closed, but opened (deprived of current) by the presence of a train on their block, the wheels and axle forming a short circuit. This relay operates a direct-current relay to send battery current to signals as desired.

Under the present arrangement, the approach has been divided into five lengths, decreasing in magnitude as the station signal is neared (Fig. 18). At the end of each one of these lengths a signal with automatic stop is placed and these operate in the following manner to permit the approaching train to come up to the station signal and the rear of the standing train.

With two trains in the position shown, Signals 2, 3, 4, 5, 6 and 7 are at "stop" indication. Signal 1 is clear, but the distant signal is at caution. (Should any of the track sections between Signals 1 and 6 be occupied the diagram shows that Signal 1 would not be clear, the relays *R*-1, *R*-2, or *R*-3 being deprived of current by the short circuiting of the track circuit.) The automatic trip at Signal 2 is up, but they are down at all other signals, that at Signal 1 being cleared by a circuit through a contactor on the signal, and those at Signals 3, 4, 5, 6 and 7 being held down by what is known as a "rear control" circuit. Thus at Signal 3 the trip did not come up when Signal 3 went to danger because Signal 2 having previously gone to danger established a circuit holding the trip at Signal 3 down until Signal 2 clears again. Then Signal 3 being at danger, the trip is at danger when a train approaches.

When the train passes No. 1, this sig-

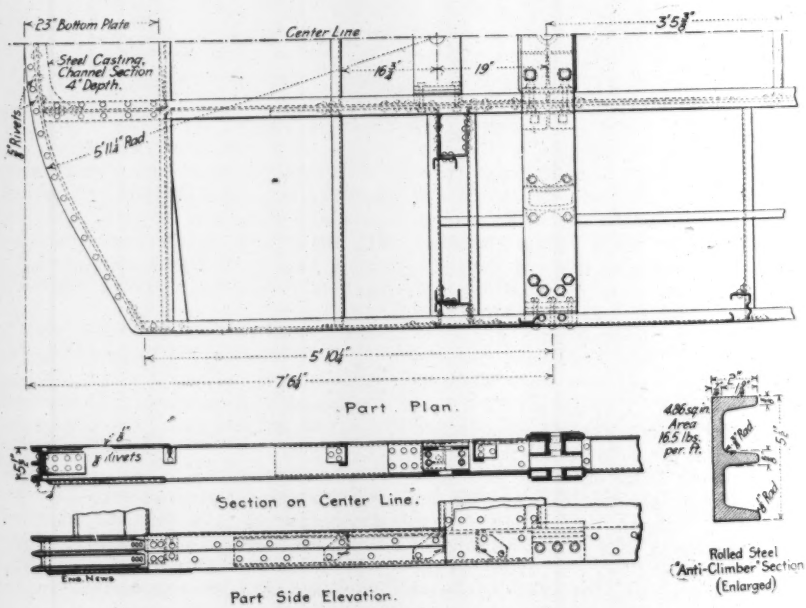


Fig. 17. "Anti-Climber" Steel-Car Platform End

nal goes to the danger position and starts the timing mechanism shown in Figs. 18 and 19. This closes the contacts *B* after a definite interval and sends bat-

2, 3, 4, 5 or 6, then such of these signals as are ahead of the train would clear as the departing train clears the proper points *W*, *X*, *Y* or *Z*.

ony Division of the New York, New Haven & Hartford R.R. where it crosses the canal lines has been carried on throughout the year and is now completed with the exception of stations at

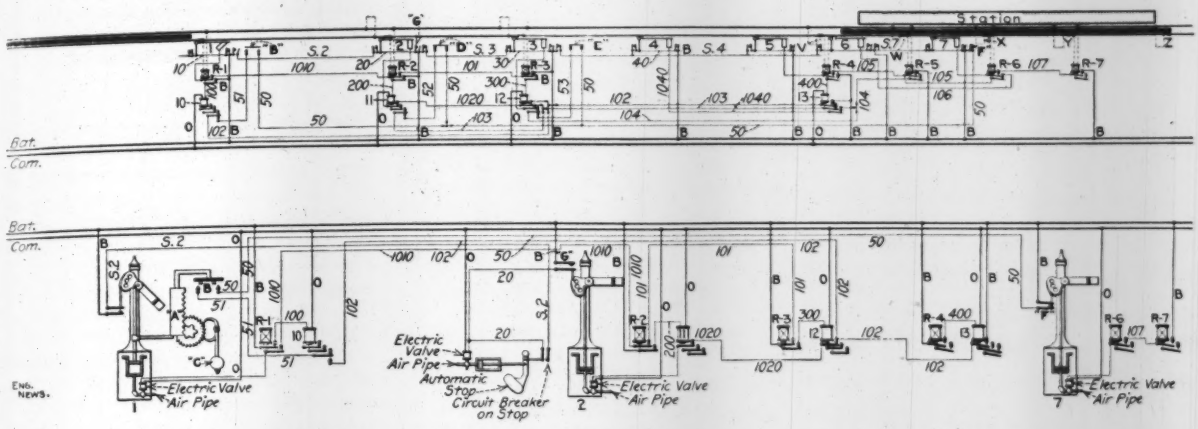


FIG. 18. PARTIAL DIAGRAM OF SPEED-CONTROL SIGNAL CIRCUITS; NEW YORK SUBWAY

tery current through the control magnet of Signal 2, clearing it; the automatic trip clears also being tied in with the signal. Once the track trip at Signal 2 has dropped, with Signal 1 at stop, the trip is kept down by Signal 1 irrespective of the action of Signal 2. The contacts "B" at Signal 1 are not closed until a predetermined interval of time has elapsed corresponding to the time required to reach Signal 2 at proper reduced speed.

After the front of the train passes Signal 2, this in turn goes to danger at once and starts a second timing device, which, after a still longer interval than the first, closes the contacts at *D* (Fig. 18) and brings Signal 3 to clear, so that the train can pass unless it reaches it before the time required at proper further reduced speed. If the rear end of the train in the station has passed the insulating joint *W*, Signal 4 will also be cleared if the approaching train consumes more than a predetermined time moving from Signal 3 to Signal 4, but with the train in the station in the position shown the approaching train will be stopped at Signal 4. When the train starts from the station and the rear end passes the joint *W*, Signal 4 clears and the motorman of the approaching train can move toward Signal 5. This signal will clear when the rear end of the train leaving the station passes the joint *X* and in like manner Signals 6 and 7 will clear as the departing train passes *Y* and *Z*.

Signals 1 to 7 are so spaced that the approaching train can move in without interruption, assuming normal delay of the train before in unloading, loading, and moving out of the station. Thus the time of stopping and restarting and of covering the approach is eliminated. Should the train in the station pull out before the approaching train reached Signal

The diagrams shown are for the simplest case; the circuits become extremely complicated when the speed-control signals are involved with the interlocking.

Progress on the Cape Cod Canal—Work on the Sandwich Breakwater was carried on from March to December, 1911, and at the end of the year was more than three-fourths completed. The side slope on the north was practically finished for the entire length of nearly 3000 ft. The principal work remaining to be done consists of placing facing stones on the southerly slope toward the canal. Large blocks have been placed to the finished top grade for almost the entire length and width.

From the easterly entrance of the canal dredging has been carried westward, and the entire prism has been excavated for the first two miles. The hydraulic dredge "General Mackenzie," is now working at the head of the cut westward of the Sagamore road crossing, making an advance of about 30 ft. per day, while a dipper dredge is making full section 1000 ft. astern.

Work of riprapping the canal banks to protect the slopes from erosion, between high- and low-water marks, was started during the summer and approximately one mile of bank has been protected.

At the westerly entrance, the five-mile channel in Buzzards Bay is two-thirds completed, and there is a continuous channel of 20 ft. depth for the first three miles, with a 15-ft. channel as far as the mouth of the Monument River. Three dipper dredges and a ladder dredge have been employed during the past season in the approach channel. In the Monument River a hydraulic dredge has excavated a 15-ft. channel from the mouth eastward to the new railroad bridge, and is now working eastward from the latter point, material from this dredge being deposited ashore on available low territory, while all spoil from the Buzzards Bay channel dredges is taken to the prescribed dumping grounds in the bay.

Work of reconstructing the Old Colony Division of the New York, New Haven & Hartford R.R. where it crosses the canal lines has been carried on throughout the year and is now completed with the exception of stations at Bourne and Bournedale. As soon as the necessary rearranging can be made in the Buzzards Bay yard and for the stations at Bourne and Bournedale, the entire relocated line can be operated and the old line discontinued.

The canal is about 45 per cent. completed (Jan. 1, 1912).

The Growth of the Automobile Industry in the United States is outlined in a bulletin recently issued by the U. S. Census Bureau. The aggregate value of automobiles passing through ports of the United States during the last ten years exceeded $100,000,000, distributed approximately as follows: Imports, $27,000,000; exports to foreign countries, $70,000,000; shipments to Porto Rico, Hawaii and Alaska, $5,000,000. The course of our trade in import and export of automobiles during the past ten years is shown by the following table:

	Imports	Exports	Shipments to noncontiguous territories
1902	$550,000	$1,069,782	$34,794
1906	4,910,208	4,499,186	185,870
1910	2,737,208	14,030,226	1,458,650
1911	2,446,248	21,636,661	1,843,165

The rapid increase in exports of automobiles from the United States is due in part to the rapid development of the domestic industry and in part to the growing use of vehicles of this character throughout the world. In 1900 the value of automobiles manufactured in the United States was $5,000,000; in 1905, $30,000,000; and in 1909, $249,000,000. It is plain that the increased consumption of automobiles in this country is being largely supplied by machines of domestic manufacture, since the imports have greatly decreased during a period in which the domestic production has grown from $5,000,000 to nearly 50 times that amount.

France is the chief source of automobiles imported into the United States, and most of the automobiles exported from the United States go to British territories. The value exported to Canada in 1902 was $37,439, while in 1910 it had increased to $4,383,487 and in 1911 to more than $7,000,000, or about one-third the total value of automobile exports from this country.

Pittsburg Sewage Disposal Reports

Plans for sewage purification works for Pittsburg were ordered early in 1910 by the State Department of Health, with the suggestion that the sewage proper ought to be separated from the storm water and that surrounding municipalities be included in the whole scheme. Hazen & Whipple were engaged to investigate and report on the subject. They estimate that the "first installment" of separation and purification works for Pittsburg alone would cost $37,300,000 and advise that this expense, or in fact any heavy outlay for the purposes stated, is quite uncalled for. Their conclusions are concurred in by F. P. Stearns and H. P. Eddy and also by N. S. Sprague, Superintendent of the Bureau of Construction of Pittsburg. The latter presents statements showing how the heavy outlay named would adversely affect the city.

To meet the demands of the State Department of Health, the city of Pittsburg has had prepared plans and estimates for separating the storm water from the sewage of the city and for purifying the latter to a high degree. While these plans have been submitted as demanded, the report reviewing the whole subject of sewage disposal at Pittsburg, which accompanies the plans and which was prepared, like the plans themselves, by Hazen & Whipple, of New York City, is from beginning to end a strong protest against the necessity of any such purification works as were apparently contemplated by the State Department of Health in its order. In fact, the report is a protest against either the construction of a separate system of sewers or any treatment of the sewage as a whole at the present time.

The report of Hazen & Whipple is concurred in by Frederick P. Stearns and Harrison P. Eddy, of Boston, Mass., who, in view of the great importance of the subject to all concerned, were employed by the city to consider the order of the State Board of Health, the report of Hazen & Whipple and the sewage-disposal problem generally at Pittsburg. The reports and recommendations of all four of these eminent engineers are indorsed by N. S. Sprague, Superintendent of the Bureau of Construction of Pittsburg, in a report dated Feb. 2, 1912, in which he transmits the reports of the engineers to Joseph G. Armstrong, Director of Public Works of Pittsburg.

If, as it is reasonable to assume, the Director of Public Works, the Mayor and the small but able Council of nine members, which now acts as the legislative body of Pittsburg, also indorse the reports of the four engineers and of the Superintendent of the Bureau of Construction, there will be presented the very interesting situation of the second largest city of Pennsylvania, protesting in the strongest possible respectable terms against the apparent intention of the State Department of Health to compel Pittsburg to install a separate system of sewers and to purify its sewage to a drinking-water standard. Perhaps, however, the department named will regard the terms of its "permits" as like a court order to "show cause" in a suit asking for an injunction and in the light of the evidence submitted in the reports mentioned will consider the case as proven against itself. The outcome of this issue will be awaited with interest. Comment on the subject may be found in our editorial columns.

Before proceeding to outline the substance of the reports, a word of explanation may be given as to the control over sewage disposal in Pennsylvania exercised by the State Department of Health. As the statutes of that commonwealth have read for a half dozen years or so past, no municipality can construct or extend a sewerage system without the consent of the State Department of Health, which consent must be concurred in by the governor and the attorney general of the state. All plans for sewerage extensions and for sewage disposal must be submitted to the State Department of Health for approval. Dr. Samuel G. Dixon, who since 1905 has been the very able and vigorous incumbent of the office named, has construed the law as giving him, in conjunction with the governor and attorney general, virtually absolute control over the present and future sewage disposal of any community coming to his department for approval of plans for sewerage. In the case of Pittsburg, Doctor Dixon merely waited until or took advantage of the fact that the city had applied for the approval of extensions to the sewerage system in each of the main drainage districts of the city to lay down the conditions that the extensions might be made, providing that by Dec. 1, 1911, plans for purifying the sewage were submitted to his department for approval. The permits (see our issue of Feb. 12, 1910, for a lengthy article drawn from the 100 pages of typewritten matter covering these) did not state in so many words that sewage-purification works must be installed, but not only was that the implication naturally drawn from the permit, but the permit stated with unmistakable definiteness what would be expected in the way of purification, and gave as the opinion of the department that a separate or sanitary system of sewers ought to be constructed and that both the collecting systems and the disposal works ought to be made to cover not only Pittsburg, but also a large outlying district.

The General Problem

In opening their report, Messrs. Hazen & Whipple state that the "plan now presented has been arranged to conform, as far as possible, with the requirements and wishes of the Commissioner of Health, as expressed" in the permits of Jan. 15, 1910. They also state that the purification of sewage as required by the Commissioner of Health "is solely from the standpoint of drinking waters taken from the Ohio River below the" various sewer outlets of the city, and they add that "there is no suggestion in any of the permits that other objects than the protection of water supplies are to be attained, or desired, as a result of carrying out the works that are proposed."

The engineers go on to say that in all the history of sewage purification there have been two objects: (1) The prevention of local nuisance or offences to eye or nose in the stream or lands adjacent to the stream receiving the sewage; and (2) the improvement of the "qualities of public water supplies drawn from the rivers below" the sewer outlets. Another object, which, however, does not apply at Pittsburg, is the protection of shell-fish from sewage pollution.

Nearly all the large sewage-purification works in the world have been constructed and are being operated solely to prevent local nuisance. The few exceptions have been in the case of small cities or villages located upon sparsely populated drainage areas drawn upon for the water supplies of large cities. In such cases special means of sewage purification have been employed "which may not be applicable in the case of a large city," and in most cases the cost of treatment has been borne by the city whose water supply was protected by the sewage-purification works. To put the whole history and present practice of sewage disposal by purification somewhat differently, the authors of the report state in effect that the practically universal object of sewage-purification plants thus far has been the removal "from the sewage of those substances which tend to the production of local nuisances" rather than the removal or reduction of bacteria.

The authors then go on to say:

> To install such works for the collection and treatment of sewage as have been installed in practically all of the larger American cities that have installed sewage purification works, would fail to prevent the passage of infectious material to the river, and would, therefore, fail of accomplishing the desired purpose. If the work is worth doing at all, it is worth doing well, and the matter is, therefore, now taken up on a basis of considering only those methods which will be reasonably efficient and

certain in stopping the passage of infectious matter.

The fundamental difference between this point of view, and that which has obtained in other cases where sewage has been collected and treated, cannot be too strongly emphasized, because the precedents of other cases are not such that they can be followed in this case.

With this preview, the report goes on to outline in detail the investigation made by the engineers. Acknowledgment is made of the assistance rendered in Mr. Sprague's office by Mr. Reppert and able assistants who appeared to have devoted themselves chiefly to the preparation of plans for changing from the combined to the separate system of sewerage and for intercepting sewers.

During the investigations a chemical and biological laboratory for examination of sewage and water was established and operated; sewage gagings were made; estimates were also made of the flow of the rivers at Pittsburg for the past six years, and in general all local conditions bearing upon the subject of sewage disposal at Pittsburg were studied.

As a preliminary to a compliance with the suggestion of the Commissioner of Health that outlying districts be embraced in the sewage-disposal scheme, an invitation was sent to adjoining municipalities to send representatives to join in a conference, but only two accepted the invitation. Nevertheless studies on a coöperative basis were made.

Beside the population of Pittsburg in 1910, which was 533,905, there are some 400,000 people in neighboring districts that might "naturally drain through Pittsburg." In the absence of knowledge as to what proportion of these might eventually join in a coöperative project, plans were based on providing for a population double that of Pittsburg and the adjoining territory, as shown by the census of 1910, or for an ultimate population of 1,900,000. It was decided that in order to comply with the requirements or suggestions of the Commissioner of Health, it would be necessary to construct separate or sanitary sewers throughout the city or district; to build intercepting sewers large enough to carry 300 gal. per capita; to pump all the sewage; to buy a sewage-purification site on Neville Island sufficiently large to treat the sewage of the whole district; and to build settling tanks, sludge collection and disposal works, works for the disinfection of the settled sewage by hypochlorite of lime, and many auxiliary structures. It seems likely, the report states, "that sprinkling filters for the oxidation of the organic matter of the sewage would be necessary either immediately, or in the not remote future, but it would be possible to obtain a partial disinfection of the sewage without their use."

Regarding the separate system of sewerage, the report points out that this is used by but a few of the larger cities of the world. Where the sewage from combined systems is treated, it has been found necessary to provide intercepting sewers to carry the dry-weather flow to the disposal works, leaving the excess, or storm-water flow, to discharge into nearby water. This is the practice at Providence, R. I., where is treated the largest volume of sewage from any one city of the United States. At Worcester, Mass., the next largest sewage-purification works in operation, the sewers were originally on the combined system, but about 60% of the city has been changed to the separate system at a cost of about $1,000,000. The sanitary sewers and sewage-disposal works of Baltimore were built but recently, and at the same time separate sewers were provided.

In the instances where sewage is treated to protect the water supplies of large cities, such as Mt. Kisco on the Croton drainage area, New York City, and Framingham, Marlboro, Westboro and Natick upon the drainage area of the Boston water-works, the sewers were not built until it was desired to protect the water supply, and then separate systems were established. All the sewage from these sewerage systems is treated, but in several cases the effluent from purification works is removed entirely from the drainage area "and the additional expenses of the systems because of the requirements of water supply, were paid by" New York and Boston, respectively.

No precedent is known for the substitution of a combined system for a separate system in order to protect the water supplies of cities below. In a combined system with overflows from the intercepting sewers, sewage-purification works, which in this case would receive the dry-weather flow only, "would fail to afford protection during those periods when the danger of infection of water supplies is greatest," since experience shows "that infection is most commonly carried by river waters at flood periods, and in the winter."

The report then goes on to show some of the difficulties and the heavy expense incident to providing a separate system of sewers for Pittsburg and for changing house connections from the present combined to the proposed separate system. Nevertheless, estimates for a separate system were made by the engineers. These were based upon an area containing about 33% of the population of the city, 22% of the total area of the city and 29% of the existing length of sewers. In designing the intercepting sewers, an allowance was made for the reduction of the present enormous water consumption by one-half so as to bring it in round numbers to 125 gal. per capita per day. For purposes of the estimate, 150 gal. per capita was taken as the average, or 300 gal. for the maximum delivery of sewage.

A pumping station with a lift of about 65 ft. would be required at the lower end of the outlet sewer on Neville Island. Centrifugal pumps direct-connected to 1200-hp. steam turbines were proposed. The stations would have boilers of a capacity of about 10,000 hp. and would require about 60,000 tons of coal per annum, or 164 tons per day when pumping the ultimate capacity of the system, or an average of 150 gal. per capita per day for a population of 1,900,000. The sewage-purification works are so laid out that they might ultimately treat the sewage of 3,000,000 people, but they would be built in installments.

Purification Works

The purification works would include grit chambers, settling tanks, sprinkling filters and final settling tanks, in which latter disinfection by hypochlorite of lime would be practiced. The settling tanks are designed with a net capacity, exclusive of space occupied by sludge, equal to three hours' flow at the rate of 150 gal. per capita, or one and one-half hours' flow at the maximum or double that rate. The sprinkling filters would be 6½ ft. deep, and are calculated to serve 12,500 population per acre. The secondary or final settling tanks would hold two hours' flow at the average rate or one hour's flow at the maximum rate. For all the settling tanks, a 20% reserve capacity was provided, but it was not thought necessary to make this allowance in the case of filters. In case the percolating filters were omitted, it might be advisable to enlarge the settling tanks, since these tanks alone "would remove only the coarsest and heaviest of the suspended matters," leaving "the dissolved matter, the colloidal matter, and the finer suspended matter" to be discharged into the river, as at present, but with the difference "that the sewage now discharged through a large number of outlets into 27 miles of river channel, with an [water] area of 3500 acres, would be concentrated at one outlet."

In introducing some remarks on the efficiency of disinfection by hypochlorite, the engineers in their reports state that the bringing of the sewage to one point and treating it by disinfection, rather than by full or complete purification, seems to be suggested by the language of the permit of the State Department of Health where it mentions bringing the sewage to one point, or a few main points, for treatment, "keeping in mind the use of the Ohio River waters below Pittsburg, and the ability of this river to receive without creating a nuisance, an effluent free from disease germs."

Speaking further of disinfection the report states:

> When applied to the effluent from sedimentation tanks, 125 lb. of hypochlorite of lime per 1,000,000 gal. is said to remove or kill 98% or 99% of germs forming acid colonies at 37° C., but it is probable that in case of a large plant, working under practical conditions, the efficiency might drop to 95%. With raw sewage 250 gal. per million gal. would be necessary, and the efficiency would probably be less than for settled sewage, due to the inability of the chlorine to

penetrate to the interior of particles of suspended matter, where large numbers of bacteria may be inclosed and protected until after the short time during which the chlorine exists in the surrounding liquid. These particles afterward are broken up and the germs therein contained disseminated throughout the liquid.

While it cannot be maintained that such treatment will cause sterilization, it may be claimed that the reduction in the number of germs will be so great as to reduce the danger now claimed to exist through the water supplies taken from the Ohio River below Pittsburg.

While the possibility of disinfecting the sewage without much other treatment is so promising that it must be considered in this case, attention is called to the fact that, if this treatment were carried out:

There would be the concentration of 60% to 70% of the putrescible organic matters of the sewage of the whole Pittsburg district at one point, and it is clear that the pollution of the river below the point of discharge would be much greater from a physical and chemical standpoint, than it is at any point at the present time.

The flow of the Ohio River is sufficient, with the present conditions of discharge, to prevent the body of the water from becoming foul at any point. It is not clear that it would be sufficient at low water stages to maintain this condition with the proposed methods of discharge at one point after settling.

Probably sprinkling filters would be necessary either at once or not far hence for use at least during low-water periods, and if sprinkling filters were to be provided, the report states, they might as well be used all the time.

The possibilities of having several instead of one sewage purification plant are briefly discussed, and it is stated that perhaps it might be advantageous or produce a slight saving in cost if one or two such plants were built to treat the sewage of remote districts.

As to the relation between sewage-purification works and the water supplies drawn from the Ohio River below, the report may be quoted briefly as follows:

It may further be noted that the water supplies for the district below Pittsburg, and included particularly in this connection, are largely taken from gravel deposits near and under the river in that portion of the river below where the main outlet would be situated, and even though complete disinfection of the sewage be assumed, the addition of so large a mass of putrescible organic matter near the points where the supplies are obtained is certainly not to be regarded as advantageous. Under these conditions, it seems necessary to include the sprinkling filters as an essential part of the whole project.

Omitting the sprinkling filters for the present would result in a reduction of the first cost of works by about 6% or 7%. There would be no saving in the cost of operation, as the additional quantity of hypochlorite of lime would offset the savings in the cost of operating filters.

The estimated cost of the first installment of the proposed undertaking is $37,300,000, making no allowances whatever for interest charges during the six or eight years that the work would be under construction. Of the sum named, $13,000,000 would go for the installation of the separate systems, $10,350,000 for main intercepting sewers, $3,000,000 for the site of purification works, $1,700,000 for the pumping station, and $4,400,000 for the sewage-purification works themselves. This would make a total of $32,450,000, to which should be added 15% for engineering and contingencies, or $4,850,000. This brings the total up to the figure named, $37,300,000. Adding to this the annual cost of operation ($435,000) capitalized at 5%, or $8,700,000, would make the total cost, including the capitalized operating expense, $46,000,000. This would provide for a population of 800,000, except that the main intercepting sewers would be sufficient to carry 300 gal. per capita from a population of 1,900,000.

The first installment of works sufficient to care for population outside of as well as within Pittsburg, and which would bring the total population provided for up to 1,400,000, would be $57,000,000. To this there should be added $725,000 per annum capitalized at 5%, for operating the main parts of the work, or $14,500,000, and $80,000 per annum capitalized at 5%, or $1,600,000, for operating auxiliary pumping stations. These two sums would bring the total cost of construction, plus capitalized operating expense, up to $73,100,000. Distributed over the population this would amount to 54c. per capita per year for the city and to a larger amount for outlying districts, on account of the auxiliary pumping.

One of the most interesting portions of the report is devoted to the effect upon the waters of the Allegheny, Monongahela and Ohio Rivers of acids from the iron works along the river and from mine wastes. These acid wastes have been increasing in amount of late and are bound, the report states, to have a profound effect upon the rivers, both as regards their capacity to receive sewage without harm and as to their availability as sources of public water supply. The exact effect at any future time, however, cannot be predicted. Present laws do not control mine drainage and, the report states, "it may be questioned whether there is any feasible and effective way of controlling it." Limited amounts of the mine drainage improve the quality of the water to which it is mixed. Iron serves as a coagulant and clarifier; it also removes other impurities. The acids act as a disinfectant, but since water containing large quantities of mine drainage is hard, saline and acid, it is necessary, in order to fit it for drinking purposes, to neutralize, soften and filter it.

Summing up this part of the subject, the report states: "For the present, and for many years to come, good water may be obtained, with proper methods of treatment, from the Allegheny and Ohio Rivers. The Monongahela has already reached the stage where it is more difficult to produce good water from it."

Water Supply of the Ohio Valley below Pittsburg

The relation of sewage disposal to the water supply of towns on the Ohio River below Pittsburg is next considered. There are 26 of these towns, with a population of 70,300 (estimated in 1909—Ed.). The value of all these works probably does not exceed two or three million dollars. None of the towns, the report states, are supplied with raw Ohio River water, as far as can be learned, "and none should be so supplied." As a rule these water supplies are drawn from filter cribs beneath the gravel near or under the river, or else from wells on the river bank. Raw or partially purified river water is used to some extent for manufacturing purposes and perhaps in some instances by unthinking people for drinking purposes. The water of the Ohio River, the report states, could be made safe by filtration just as the water of the Hudson, which is polluted by the sewage of Troy, Schenectady and other cities, is made safe by filtration in Albany, and just as are the water supplies of many other cities in this country and abroad. Some of the present works are defective, and might advantageously be improved.

Inspection of these various supplies, together with analyses of the water being furnished, "show that where proper conditions are maintained water of excellent quality is secured." On the whole the supplies from the driven wells are better than those obtained from the cribs. The water from some of the crib systems is liable to pollution from the river and should be purified before being used. This might be done by disinfection with hypochlorite of lime. After reviewing the results of bacterial examination of the water of the Allegheny and Monongahela Rivers at Pittsburg and of the Ohio below, the report continues:

It is evident that the acid in the Monongahela water destroys many of the bacteria there, and that this reduction has an important effect on the bacterial content of the Ohio River below Pittsburg, making it lower than it otherwise would be. In addition to this, the natural purification by coagulation and sedimentation that takes place in the pools back of the dams during the summer is an important influence in reducing the number of bacteria in the river waters at a time when the ground water supplies are most likely to be overdrawn.

Sewage purification works, as ordinarily built, do not give complete bacterial purification. It is hardly to be expected that more than 99% of the bacteria in sewage would be removed by any plant that could be constructed and operated at Pittsburg at reasonable cost, and a much lower average efficiency is more probable.

If purification works were built in Neville Island and the effluents discharged into the river there, under conditions such that the dilution of sewage by the river flow would be as low as 1 to 50 (at lower river stages the dilution is less than this) and the effluent thoroughly mixed with the river water, the number of B. coli in the water after receiving this effluent would probably be at least 10 p. c.c. and might be much higher. When to these are added the bacteria found in the untreated storm flow, it seems probable that the river water at points a short distance below Neville Island would still be highly contaminated from a bacterial standpoint; and that in places where the effluent is not thoroughly mixed with the water the bacterial contamination might be even greater than it now is.

Looking to a more distant future, the question of the impairments of the quality of the water by mine drainage seems more likely to be a controlling one, than the question of sewage.

The whole district might be readily supplied from impounded upland water, whenever in the future the growth of population would warrant the building of works on a large scale. The whole matter is thus summed up:

> Purifying the sewage of Pittsburg would not make the Ohio River water fit to use in its raw state. It can be made fit for use at the present time by proper filtration and treatment. The cost would be extremely small when compared with the cost of installing works for treatment of sewage of Pittsburg. Installing such water-works with proper management would insure a supply of safe water. Purifying the sewage of Pittsburg by artificial processes would make only a slight difference, and would not be a material element in the water-supply situation in the valleys below.

Moreover, taking sewage out of the rivers and carrying it to Neville Island "would have the effect of removing it to a large extent from the purifying agencies naturally existing in the river at the present time."

Considering next the general problem from the viewpoint of possible local nuisance caused by the sewage as now discharged into the river, the report states that such nuisance as now exists or is likely to exist during the next twenty years will not justify intercepting sewers and the construction of sprinkling filters. When corrective measures are needed they can best be applied locally and at relatively small expense by building settling tanks near the outlets of some of the largest sewers.

Considering the local nuisance question as it may arise in the more distant future, the report states that the combined drainage area of the Allegheny and the Monongahela Rivers is 18,450 square miles and the average flow of the two streams about 32,000 cu.ft. per sec. During the three years 1905, 1906 and 1907 the flow did not fall below 4000 cu.ft. per sec., but in 1908 during the "greatest drought on record, the discharge fell to about 1300 cu.ft. per sec. and was below 2000 cu.ft. per sec. for three months." The low water flows of the three years 1909, 1910, 1911, which years were much drier than the average, were about 2000 ft. per sec., which "may be taken as the minimum flow of the river, below which it falls only on very exceptional occasions."

Although the low water in the Ohio River in 1908 did not provide a very great dilution even for the present sewage, when judged by American and European experience, various local conditions should be taken into account in attempting to arrive at a proper conclusion regarding sewage disposal at Pittsburg. Besides the effect of the acid iron waste upon the river, already mentioned, attention is called in the report to works already being carried out by the Johnstown Water Supply Co. and the Cambria Steel Co., near Johnstown, which will probably add about 100 cu.ft. per sec. to the dry-weather flow of the streams. Other storage works are likely to be built in the future. In fact "The Pittsburg Flood Commission is proposing the construction of a whole series of storage reservoirs." If these were built the minimum flow of the river would be increased at least 4500 cu.ft. per sec.

In view of the facts and uncertainties just stated and of the further fact that "methods of sewage purification have been developing rapidly, and are sure to develop still more" it is considered futile to try to plan sewage-disposal works to meet these conditions for any great length of time in advance.

The final conclusions of the report are as follows:

> It is recommended that for the present the method of sewage disposal by the city of Pittsburg should be by dilution in the waters of the Allegheny, Monongahela and Ohio Rivers. Dilution is a well recognized method of disposal of sewage, in general use throughout the civilized world, where the quantities of water available for dilution are sufficient in proportion to the quantities of sewage. The Pittsburg conditions are favorable for it. Ample authority and precedents can be cited if it should be necessary, but the practice is so generally adopted at the present time that a further statement in this place seems unnecessary.
>
> No radical change in the method of sewerage or of sewage disposal as now practiced by the city of Pittsburg is necessary or desirable. Additional sewers will be required as the city grows; some old sewers must be reconstructed; better outlets should be built; and the sewers for low districts should be better arranged with reference to flood conditions. These are all matters that can be taken up and carried forward from time to time.
>
> There is no occasion for the expenditure of many millions of dollars by the city at this time for radical changes in the works or in the methods of disposal.

Report by Frederick P. Stearns and Harrison P. Eddy

The report of these consulting engineers, which is dated Jan. 30, 1912, appears to be an endorsement in every particular of the conclusions and recommendations made in the report of Hazen & Whipple. These engineers agree that it is impracticable to completely protect the water supplies of the cities below Pittsburg by any treatment of the sewage of the Pittsburg district. They mention "the large and increasing capacity of rivers to take care of sewage and destroy the bacteria contained in it, and the great cost and inconvenience due to the remodelling of the sewerage system to provide a sanitary sewer and a storm-water drain in every street, and a double system of drainage for nearly every building." They also state that the time has not yet come for making definite comprehensive plans for treating sewage and add that when the treatment of sewage does become necessary it is likely that a treatment need be applied to only a part of the sewage "sufficient to prevent offensive conditions in the rivers."

Report by N. S. Sprague, Superintendent, Bureau of Construction

As stated at the outset of this article, the report of N. S. Sprague, transmitting the report of the consulting engineers to Joseph G. Armstrong, Director of Department of Public Works, is a complete endorsement of the opinions of those engineers.

Mr. Sprague states that in 1909 an appropriation of $40,000 was made by the city of Pittsburg for the purpose of carrying on the investigation and preparing the plans made necessary by the orders and permits granted by the Commissioner of Health. Hazen & Whipple were appointed as engineers on Jan. 26, 1910. Before this date, however, considerable progress had been made in the collection of data bearing on the problem. The major portion of Mr. Sprague's report is as follows:

> The estimated cost of sewerage works to provide for the needs of the city as at present constituted, but for a population of 800,000 people, which will comply with the requirements of the State Commissioner of Health, is $37,300,000, exclusive of the capitalized cost of operation. The question which the taxpayers of Pittsburg will naturally ask is: Is this expense necessary and warranted and what benefits will accrue to the city by reason of this enormous expenditure and the consequent interruption and interference with business incident to the execution of the project?
>
> The reasons set forth in the decree from the state for the sewerage works, are to prevent the pollution of the river waters from sewage and to render more safe their use for water-supply purposes. It is admitted by all who have a knowledge of these matters that, under existing conditions and laws, no amount of sewage purification works would insure the purity of the water in these rivers to make it safe for water-supply purposes without water-filtration works.
>
> The city has already expended about $7,000,000 for the building of a water-filtration system at Aspinwall, the source of supply being from the Allegheny River, and it was recognized at that time that this was the only safe means of securing a quality of water which would not be polluted by sewage. Assuming these sewage works are built at a cost of $38,000,000, the purity of the water supply below the city can only be insured against pollution by the building of proper water-filtration works. Then the question may properly be asked, Wherein is the benefit to be derived from this great outlay, and how will it tend to conserve the health and life of the people?
>
> It is stated in the report that the value of the various water-works below the city is between two and three million dollars and that these supplies can be filtered and made safe for domestic purposes for a sum considerably less than this amount. As a business proposition it would be many times cheaper for the city, provided the laws would permit, for the city to build the necessary water-filtration works for these supplies or possibly supply them with water from the plant at Aspinwall, or, if this is impracticable, to build a new central plant below the city adequate to supply the needs of this population. In either case many millions of dollars would be saved and the interests of public health would be greatly conserved thereby. The Pittsburg water-filtration plant has prevented typhoid fever, saved many lives

and is worth all it costs, but I fail to see how the building of the sewage-purification works and the great outlay of public funds would save a single life. Practical sanitation means the greatest good for the greatest number, and would it not be a better policy to conserve the public funds and apply them to other sanitary measures which would produce far greater results?

The financial side of this question must also be considered. The assessed valuation of the city is $750,000,000. The statutory limit of bonding power of the city is 7% of the assessed valuation, which would produce a revenue of $52,500,000. The present bonded debt of the city is $41,794,161. After deducting bonds and cash held in sinking funds and floating debt, all of which amounts to $13,102,851, there appears to be a margin of $28,691,310. While it is true that only a portion of the funds would be required at the start, yet authority for the sale of the full amount must be obtained previous to the letting of contracts. It is, therefore, apparent that legislation looking toward increasing the debt limit of the city must be enacted in order to execute the project. In other words, the Commissioner of Health, in his decree to the city, has ordered an undertaking which the city is not financially able to assume.

Another matter which, I think, should be given serious consideration in connection with this report and which relates to the separate system of sewers is the expense which must be incurred by all owners of buildings for the rearrangement and alterations in the plumbing and sewer connections necessary to carry out the project. The cost of this individual work varies, as stated in the report, and this expense no doubt will be a hardship upon many of the smaller property owners. The task of enforcing the changes in house plumbing and sewer connections to conform to the proposed system is not an easy one and would require many years for its enforcement, if possible at all. I am informed that, in the city of Baltimore, which had no sewers of any kind and which is now sewered on the separate plan, and notwithstanding the works have been completed for about a year, only 100 houses out of a total of 125,000 have made the necessary changes in their house plumbing. In the city of Worcester these changes were only made after much effort and a considerable lapse of time.

The rivers are the natural and logical drains and are formed for the purpose of carrying the wastes to the sea. When the amount of such wastes discharged into the rivers produces a nuisance it is then time to adopt remedial measures for its abatement. From my knowledge of the sanitary condition of the Monongahela, Allegheny and Ohio Rivers this time has not yet arrived, and, in my judgment, the requirements of the state are unwarranted and would fail to accomplish their purpose. I therefore agree with the conclusions reached by the consulting engineers and approve of their reports upon this subject.

A 525-ft. Steel Arch Bridge is being built in Africa by the Gutehoffnungshütte for the German government. It is to provide a railway crossing over the Sananga River, in Kamerun. In November, 1911, the second half of the arch was floated into place, according to the "Zeitschrift des Vereines deutscher Ingenieure" of Feb. 10, 1912.

A Machine for Economical Handling of Coal and Broken Stone

By Horace Goldstein*

In Engineering News of June 22, 1911, p. 765, there was described a dumping chute for facilitating the unloading of coal and broken stone from cars into waiting wagons. This is but one of a series of devices which may be expected in the future to cheapen the handling of such materials; another device of equal use and economy is shown in the accompanying figure. It consists of a small bucket elevator on a truck and has been designed to load from open piles into wagons. Anthracite or bituminous coal with 8-in. lumps can be loaded.

The elevator head shaft is chain driven from a countershaft to which a motor (or gasoline engine) is geared. The small sprocket is thrown into action by a friction clutch. The elevator frame is pivoted at the top so that the scoop end can be raised or lowered to suit the ground or to clean up the last of a pile. The machine shown has a capacity of about a ton a minute. It costs, complete with gasoline engine or electric motor, about $850. Comparative observations of the machine in use in a coal yard and of hand loading show the following costs per ton:

A Portable Elevator for Loading Coal and Stone from Open Piles

(Built by the Link-Belt Co., Philadelphia, Penn.)

	Hand loading	Machine loading
Interest	....	2.55c.
Maintenance	....	1.25c.
Depreciation	....	2.12c.
Power	....	0.37c.
Team and driver	15c.	5.00c.
Yard helper	5c.	1.25c.
	20c.	12.54c.

This is based on loading only 10 tons of coal per day for a year of 200 days; interest is taken at 6%, maintenance and repairs at $25, depreciation at 5%, power at 10c. per kw.-hr., team and driver at 45c. per hour, yard helper at 15c.

When desired, the head chute is made, without extrat cost, with a screen plate. The extra cost of screening is the only thing compared with about 6.6c. b[illegible]d, making the total saving on a [illegible] of screened coal 14c.

These figures are for a very small use of the loader—about 10 minutes of actual operation. The ton cost for power, team and men are fixed, but the other costs decrease with increasing use. If 50 minutes average actual operation for a day can be secured, then the cost per ton for loading and screening drops to 7.8c. and the saving per ton amounts to 18.8c. The annual saving for the smaller use (unscreened) amounts to $149 ($281 for screened coal); for the larger use it rises to $1240 for unscreened and 1880 for screened coal. It is evident that the machine would pay for itself in a year in a medium-sized yard. The figures quoted are for handling coal, but they should be about the same for handling broken stone, etc.

*Link-Belt Co., Philadelphia, Penn.

The Status of the Wood-distilling Industry in the United States for the year 1910 is the subject of Forest Products Bulletin No. 7, compiled by the Census Bureau and Forest Service, and recently issued. This shows that, in 1910, 147 concerns reported using 1,450,439 cords of wood, which is an increase of 14.6% over the quantity used in 1909 by the same number of establishments; 86.7% of the wood consumed was hard wood. Of these establishments 117 were hardwood distillers, this being one more than for 1909, while the consumption of wood was 9.4% greater. Of the materials used about 60% was body, 30% limb, and the remainder largely slabs and mill waste. The principal hardwoods used are beech, birch and maple, and the destructive process is commonly employed. Charcoal, crude wood alcohol and gray acetate of lime were the leading products. Usually a cord of hardwood furnishes from 45 to 52 bu. of charcoal, 7 to 10 gal. of wood alcohol, and from 130 to 200 lb. of acetate of lime.

The number of softwood distillers was 30, or one less than for 1909. The total consumption of softwoods was 192,442 cords, or a gain of 66.9% over the preceding year. Of the softwoods consumed 50% was body, 25% sawdust, slabs and mill waste, and 25% limbs and stumps. Southern pines were most used, and long leaf formed the bulk. Both destructive and steam processes were used, the principal products of the softwood distillers being turpentine, charcoal and heavy rosin oils.

A Reorganization of the Garbage Collection System of Milwaukee has been recommended by the Bureau of Economy and Efficiency of that city, as a result of a study and report (Bull. 12) made by Robert E. Goodell under the Director, B. M. Rastall. It is believed that if the city was redistricted, the collector worked a full eight-hour day and each was responsible for his district, that the number of wagons and men could be reduced from 96 to 75 per day and $17,262 saved as a result. It is suggested that $846 of the saving be used to pay the wages of an "engineer" at the incinerating plant who would wash each wagon box daily and disinfect each weekly.

Letters to the Editor

The Prest-O-Lite Building Failure and the Design of Flat Slabs

Sir—Were we all of the same opinion on technical matters, there would be little, if any, improvement in the conduct of work. Perhaps a line on the differences in opinion between Mr. Condron and the writer (ENGINEERING NEWS, Feb. 8, 1912, p. 261) may bear further discussion in the interest of the progress and the safe conduct of concrete construction.

The writer's observation of many buildings put up in chilly, frosty weather, is that where the water has not been heated in mixing, as was the case in the Prest-O-Lite job, six weeks' time at temperatures there recorded does not usually cure the concrete. The assumption that this short period should usually cure the concrete

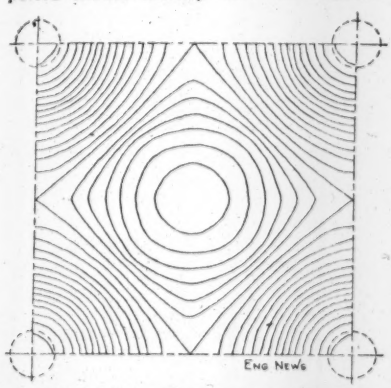


FIG. 1. CONTOUR DIAGRAM OF A RUBBER PLATE SUPPORTED BY COLUMNS AND UNDER LOAD

(Published by the Corrugated Bar Co. of St. Louis.)

unless there were indeed some fatal malady in the mix, has many times led to needless difficulties in the concrete business. The fact that the hardening of concrete is a chemical proposition retarded by cold and further that when the concrete has once been chilled there is no known rule for gaging the rapidity of this hardening process in point of time, does not seem to be as well understood as it should be. The only absolutely reliable criterion is to examine the concrete and determine how hard and rigid it is and for the constructor to form his judgment, not upon the number of days he has kept his supports in, but really on how hard and well cured the concrete proves to be by investigating its hardness in a practical manner.

Referring to the Gallun Tannery, Mr. Condron merely assumes that there must have been cracks with a deflection of 1/260th of the span on the upper part of the slab at the column. None were observed and the writer has never seen any in this portion of the mushroom system under test in well cured work, as in this type of construction that part of the slab, owing to the concentration of metal at that point, is much stronger relatively than the balance of the slab.

Mr. Condron evidently has a very poor opinion of the education of the average reader of the ENGINEERING NEWS if he assumes that it is putting a puzzle before the readers of the paper if one makes the plain statement that the circumference of a circle is $2\pi R$, or approximately $6^2/_7$ times its radius, and the geometrical relation of radial and circular distortion in the flat plate supported by the column bears this direct ratio, as is illustrated by the accompanying Fig. 2. Perhaps it would be better to supplement the figure by referring to a neat little contour diagram appearing in a pamphlet issued by the Corrugated Bar Co., of St. Louis, in which measurements were taken on the deflections of a rubber plate supported at points (Fig. 1). These contour lines bear some resemblance to a floor plate (at least in the preliminary stage of the load, in the test) as regards the general character of the curves. This contour diagram shows very clearly the plate bending downward around and in the vicinity of the column forming contour lines circular or approximately circular in form. Considering then the radial elongation as per the attached Fig. 2, the top fibers are elongated at any section within the line of contraflexure an amount which we will assume ΔR. Now, by referring to the contour map, radial elongation would mean a circular enlargement of the plate on the top and a deformation in a circumferential direction $2\pi\Delta R$, or approximately $6^2/_7$ times the radial distortion.

The mere fact that some theorists do not know and are merely guessing how Poisson's ratio in reinforced concrete is affected by steel running in two or more directions in no wise alters the fact that there are positive deformations in a slab under bending which have certain fixed geometrical ratios to each other and that these ratios may be readily expressed in a fairly complete and accurate manner. If the circular distortion is practically $6^2/_7$ as great as the radial distortion it would seem evident that the steel arranged in such location as to resist directly the maximum distortion would be more efficient than arranged in any other manner. Thus reinforcing rods in four directions, being tangent to the circular sections at eight points, are in better position to resist circular as well as radial stresses than rods arranged in two directions, and further reinforcement in flat spiral form should be in better position to resist economically these stresses than the four-way reinforcement. On the other hand, the four-way reinforcement combines resistance to shear with resistance to circular stresses and we cannot eliminate it entirely but may combine it advantageously with the spiral steel. Such a combination is shown in the reinforcing for the Diamond Creamery building (Fig. 3), in which spiral steel is used throughout the central portion of the slab diagonally and circular reinforcements over the head of the column, and flat

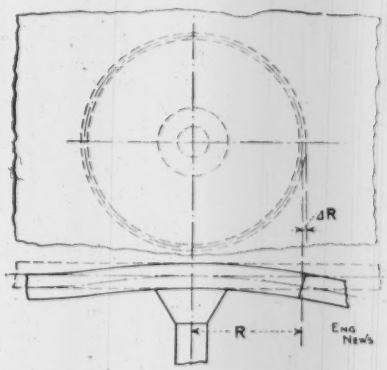


FIG. 2. DIAGRAM ILLUSTRATING THE DEFORMATION OF A FLAT FLOOR SLAB UNDER LOAD

spiral reinforcement between the columns.

With the above explanation the writer's remarks as to circular and radial deformations in the flat plate will appear self evident on their face and the mystery surrounding the resistance to bending stresses by circular as well as radial stresses will disappear in the minds of many of your readers, if they will consider the necessary geometrical relations of strain and deformation under bending in various directions in the flat plate.

Attention is further directed to the fact that the suspended span portion of the slab about a center formed by the intersection of the diagonals of the panel presents the same character of deformation concave downward in all directions. This is the reverse of the deformation of the plate around the column which when

bent presents a convex surface on top, and hence the resistance to the circular distortions about the two axes that is the center line of column and the vertical through the diagonal center of the panel is similar, the reinforcement arranged to resist directly stresses in the circular direction should seemingly be the most efficient that can be used. Experimental data at the present time are somewhat too meager to go into complete discussion from the standpoint of coefficients. It will, however, present an interesting puzzle for those mathematically inclined to work upon.

C. A. P. TURNER.

Minneapolis, Minn., Feb. 12, 1912.

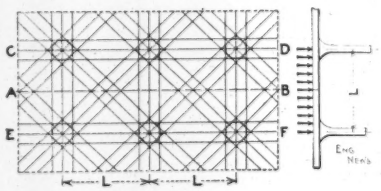
Sir—The discussion of flat slabs by Messrs. Condron and Turner suggests some queries to me.

Mr. Turner says, "The bending moment is resisted more largely by circular than by radial stresses." It is no doubt true that a flat-steel plate supported on four sides will derive a large part of its sustaining power from circular stresses. These stresses will be both tensile and compressive. In a reinforced-concrete flat slab are the circular *tensile* stresses (those due to downward dishing of the slab) ever calculated and is the concrete ever reinforced to take these stresses?

There is no doubt that the dishing of a flat plate or slab supported on posts is a large factor in the carrying capacity of an interior panel because of the tensile strength of the surrounding slab and its reinforcement. A cloth sheet will support a large load if pulled out in every direction. But what about the case where a row of panels entirely across a building is loaded and the tendency is to take a cylindrical instead of a dished shape, when the adjacent slabs cannot pull, because there is nothing to push against except the loaded slab? Is not the flat slab then in simple bending with nothing else to cling to, not even Poisson's ratio?

Would a flat slab supported on posts be weakened by introducing supporting girders between the columns in one direction? Would the slab not then be a simple slab amenable to the laws set forth in the theory of flexure?

Angus B. McMillan's method of reinforcing a flat slab (ENGINEERING NEWS, March 31, 1910) is to take the total load on a bay and multiply it by $^1/_{25}$ of the span and, dividing this bending moment into four, to place rods in each of the four directions so as to reinforce the slab for the same.



FLAT SLAB CROSSED WITH BEAMS
(Diagram suggested by Mr. Godfrey.)

Mr. C. A. P. Turner's method is to use $^1/_{50}$ of the span in place of $^1/_{25}$ (same reference).

Now for each bay cut by the line AB in the above figure there are three sets of rods intersected. Two of these are at 45°. The pull of two forces of unity at 45° with AB is equivalent to a pull of 1.4 at right angles to AB. The total of the three sets is then 2.4 as reinforcement in the bottom of the slab at the section AB.

The total resisting moment per bay on an indefinite line AB is then $^{24}/_{40}$ of $^1/_{25}\,W = 0.024\,W$ for McMillan's slab and $0.012\,W$ for Turner's.

If the slab were not balanced beyond the column lines, it would approach a simple span with the moment $0.125\,W$, about ten times Turner's moment and five times McMillan's. Otherwise the columns would have to take the bending.

Suppose the slab were balanced at the column lines. The bending moment at the center of span for a fixed slab is $0.042\,W$; 1¾ times McMillan's moment and 3½ times Turner's. The bending moment over the supports is double this.

Does this not look like placing large dependence upon the transverse strength of plain concrete? Does it not look like

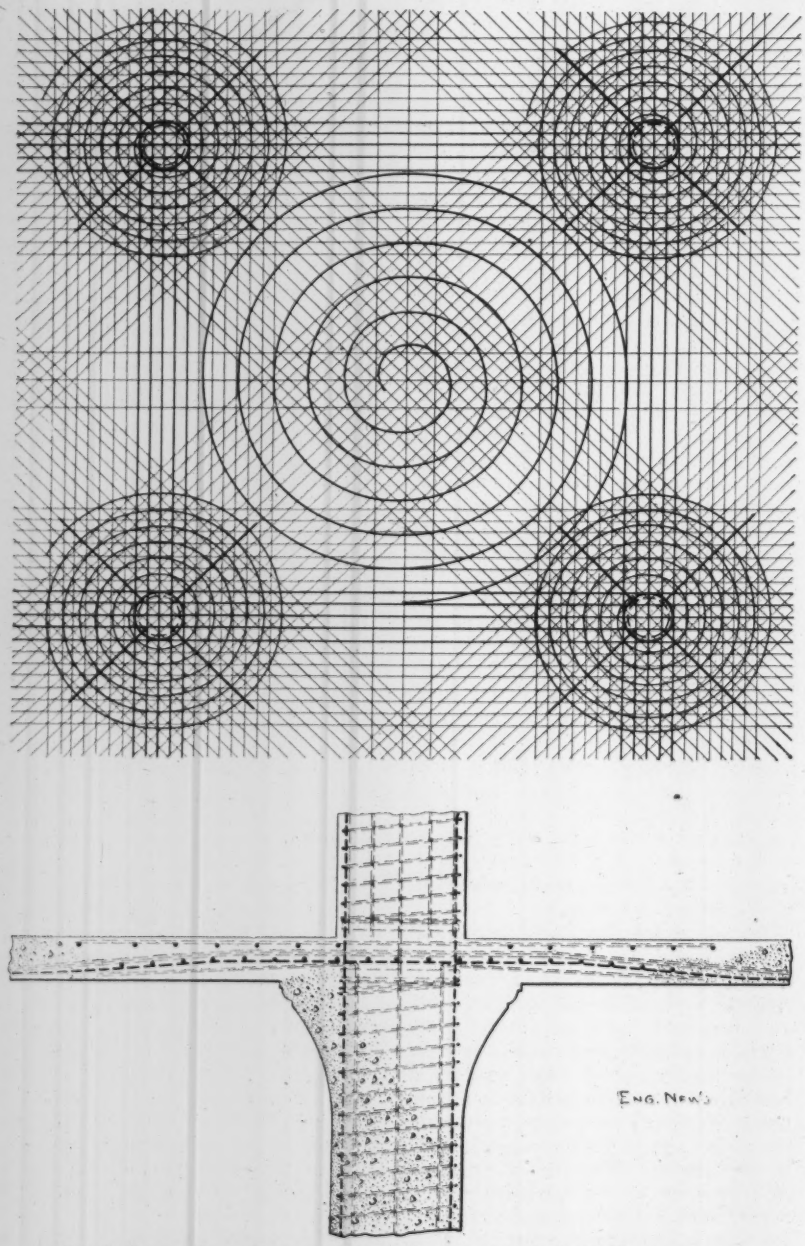


FIG. 3. SPIRAL SLAB REINFORCEMENT DEVISED BY C. A. P. TURNER.

taking long chances on the probability of a building never receiving its full load from wall to wall along a row of panels?

EDWARD GODFREY.

Pittsburg, Penn., Feb. 10, 1912.

Sir—I read the two articles by T. L. Condron, on the collapse of the Prest-O Lite Building at Indianapolis, in ENGINEERING NEWS, Dec. 28, 1911, and Jan. 11, 1912, respectively, with great interest and appreciation; but, since I had an opportunity of inspecting the ruins and taking notes thereon, several days before Mr. Condron reached here (on the following morning, in fact), I take the liberty of calling attention to a few matters which may serve in drawing out the most complete information.

I have not had the privilege of inspecting the original plans, so the drawings I submit herewith and shall refer to below, are made from my own measurements and observations at the site.

In stating (p. 780), that the steel reinforcement consisted of "cold-twisted mild steel bars," his information was at variance with mine, it having been stated

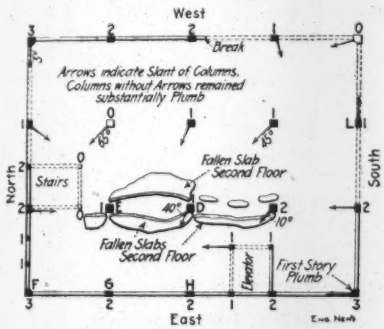


FIG. 1. PLAN OF PREST-O-LITE BUILDING AT SECOND FLOOR LEVEL, AFTER FAILURE

to me from two different sources that the bars were hot twisted scrap, which is confirmed by their behavior, as to breakage (as set forth below), when the failure occurred. Mr. Condron further states (2d article, p. 69), that "no bars were broken so far as the writer knows." As a matter of fact, I found, the morning after the wreck, before any clearing up had been done, except as necessary to take out the killed and wounded, quite a few broken bars, snapped off like sticks of candy; there was no visible evidence of that stretching of the bars beyond their elastic limit, rightfully mentioned by Mr. Condron as their proper action, nor any reduction of area at the point of fracture, visible to the naked eye. In my sketch, Fig. 4, I have shown an instance. It is true that many bars among the tangled wreckage had to be severed by using blow pipes, in order to get the men out; but the fused appearance of these ends was plainly distinguishable from the true breaks caused by the failure. That many more bars were not broken may possibly be attributed to the fact that much of the concrete had so poor a grip on the bars as to be cleanly stripped therefrom, and to quite an extent the bars were also pulled bodily out of their end anchorages.

In discussing the cause of failure, Mr. Condron does not claim, but seems clearly to imply, that the bars were overstressed to the breaking point. If it were true that they were of cold-twisted mild steel, his figures, ingenious as they are, surely do not bear out this theory. But if they were scrap bars, it might be (to speak Hibernically) that their ultimate strength was of unknown weakness. However, I was struck by two things that I have never seen mentioned by any one in a public discussion of the matter. These are, (1) the interference by the stair and elevator wells with the floor design (see Fig. 1, p. 780, Dec. 28, 1911), and the inadequate manner this was provided against, and (2) the design and construction of the wall spandrels, which I have shown in my Fig. 2 herewith. Both of the spandrels I have shown in my Figs. 3 and 4 may be well seen in perspective in the first photograph in your issue of Dec. 14, 1911, p. 717. By looking closely the sagging bars shown in elevation by me, and the break in the spandrels along the top surface of the second floor slab, as well as the great "bites" of concrete taken out above that level, may be clearly seen. The broken bar indicated in my Fig. 4 is at the right end of the second spandrel from the left. It is a significant fact that *all* the second story spandrels which remained attached to the columns, split off horizontally at the second floor level, leaving the bars exposed; and it was remarkable how cleanly the concrete detached itself not only from these bars, but also from those in the column heads.

My own theory of the cause and primal place of the failure rests on the foregoing facts, and one other as follows:

There was no basement under the building, and the column footings were surprisingly near the surface. In fact, all the leaning parts of columns I was able to inspect at the ground, did not break off at the tops of the footings, but actually twisted the footings partially out of the ground; the plane of the footing remaining normal to the axis of the column. So might it not have been, that the ground under one of the column footings (say *G*, Fig. 1) failed to bear up the superimposed weight, thus throwing such bending stresses upon the spandrels *FG* or *GH*, as to break away the adjacent floor slabs, the remainder of the building naturally following? If the second floor slab became detached from the spandrel *GH* (Fig. 1), it would naturally split along the line *ED*, shearing off the heads of columns *E* and *D*, and rotate to the ground on the axis *ED*; and this is exactly what occurred, the broken slabs resting edgewise on the ground, and the upper parts of the building falling through, going down "as through a funnel," as Mr. Condron so happily expresses it. But the other parts of the building, tending to fall *toward* the point of first failure, would move in parabolic arcs, roughly speaking, the highest parts moving the farthest laterally, and this also is what occurred. It is inconceivable that a fresh and unset roof slab, even if the shoring had failed, could break through the third floor slab, 22 days old, by its impact after so short a fall, disintegrated, as it would be, on arriving, into so much loose gravel and cinders. Nor is it conceivable that *all* the third story shoring under the roof would fail at the same instant; one panel might do so, and possibly the third floor be somewhat damaged at that point; but the remainder of the building would continue to stand. I can not ascribe so complete a wreck to any other plausible cause than a failure at the foundation, complicated by a most surprising design of wall spandrels. In these, the vertical shear at the junction of the floor slabs was provided for by the ends of the floor bars spaced about 7 in. apart; but the horizontal shear at the top of the slab was wholly unprovided for, there being a total absence of stirrups or shear members of any description. So the entire resistance to the weight of the second floor loads at the spandrels depended on the tensile strength of concrete, with such small assistance as might have been afforded by a single bar bent up near the ends.

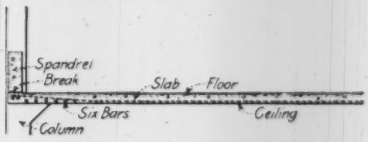


FIG. 2. TYPICAL SECTION OF SPANDREL SLAB

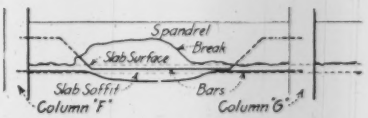


FIG. 3. ELEVATION OF SPANDREL F G (FIG. 1)

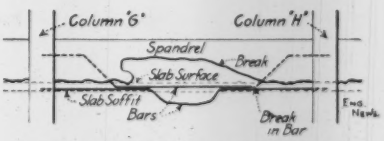


FIG. 4. ELEVATION OF SPANDREL G H (FIG. 1)

It is true that there were six ½-in. bars, 9 in. apart in the floor slab, running parallel with the wall (Fig. 2). For this reason it might be claimed that there was a broad, shallow beam next to the

wall, carrying its proportional floor load, which was to a certain extent true, the end reactions being partially on a bracket projecting from the wall column, and partially on the belt of bars coming across from the interior column. Assuming for this beam, $b = 54$ and $d = 7$, we have $bd = 378$ sq.in. against $As = (6 \times 0.25 =) 1.5$; ratio, 0.004; and solving for breaking load, at 80,000 lb. ultimate for twisted bars, $bW = 27{,}000$ lb. In the absence of exact details, it is impossible to distribute exactly the proportion of panel loads carried by this beam and the spandrel together; it appears to include about 175 sq. ft. On this basis the total panel load (roof, third and second floors, and two tiers of form work, all carried by the second floor) for the part panel carried by this suppositious beam, was, at 300 lb. per sq. ft. (Condron), for 175 sq. ft., equal to 52,500 lb., leaving (52,500 – 27,000) 25,500 lb. to be made up by the spandrel, which failed in lateral shear, as might have been expected. Which particular one failed first can hardly be determined; but as they were all alike and equally overstressed, it may readily be surmised that initial failure in any one of them, by its shock and the transmission of sudden stresses to the others, would cause them all to shear laterally as they did, either all togther or in quick succession; and such extensive failure would bring down the entire building in a single crash.

It is this feature of the wreck, its suddenness and completeness, that constitutes the puzzle; and it is to be regretted that the detailed design could not have been made public; also that no comparison was made between the actual cement delivery tickets and the calculated quantity of cement necessary for the concrete specified, so that Mr. Condron need not have been under the necessity of basing his calculations on the supposititious strength of the concrete.

In explanation of my Fig. 1, this is a plan of the second floor of the building after the wreck. All columns shown in black remained standing, or leaning at an angle of 45° or less from the vertical, the arrows showing the direction of slant, and the figures the extent of column (1, 2 or 3 stories, respectively) which remained standing. The columns shown in outline and marked *O*, either completely fell or would have done so but for lodging on débris. The directions of the arrows are very significant, it seems to me, the only exception to the general trend being at *L*, and this column was but a few inches out of plumb. The dotted lines around the perimeter show where the spandrels broke completely away from the columns, those remaining *in situ* being only at the second floor, where shown by entire lines. In every case the spandrel bars were exposed to view, the slabs breaking off substantially at the second floor level, taking the lower 8 inches or so of the spandrels with them. The first-story columns were quite hard, the second-story somewhat less so, the third-story very soft and much broken up. The second-story spandrels did not appear to be well set; those that struck the ground were badly shattered; the second-floor slabs were much harder. The effect of any shores under the second-story spandrels must have been *nil*, as they footed on bare ground that had been frozen and thawed at least once and rained on a number of times. All first-story forms had been struck, and all first-story columns stripped; all other columns were still encased, and the second and third-story forms in places before failure.

W. K. ELDRIDGE.

Indianapolis, Ind., Feb. 10, 1912.

Why Not Re-Rolled Rails for Concrete Reinforcement?

Sir—In ENGINEERING NEWS, Feb. 15, 1912, p. 305, there is a letter from E. W. Stern condemning the practice of using re-rolled railway rails for concrete reinforcement. As this appears to be a mere assertion of personal opinion, with no reasons given, the writer would like to ask Mr. Stern, as a matter of information, the grounds for his assertion.

No material is so carefully inspected, carefully analyzed, so uniform or so carefully rolled as railway rails. The subsequent re-heating and re-rolling, if properly done, can only improve the material. Every iron manufacturer knows that if it is not burnt, the more iron or steel is re-worked, the better its quality becomes.

A rail cannot be brittle; if so, it will not do duty as a rail. The recent talk about brittle rails means brittle under certain very trying conditions, and as a matter of course, the one rail, out of thousands of tons, that breaks under service is not re-rolled. The rails that have been re-rolled have stood the test for years under the most severe conditions, and the purchaser of re-rolled reinforcing bars is getting a material every bar of which has been tested. The purchaser of bars rolled directly from the billet is getting bars of which only samples can be tested. There may be a flaw in the next bar or billet to that one tested. It is a matter of common rumor, if not common knowledge, that the scabbed, piped and otherwise defective billets are used for rolling into reinforcing bars; also in many cases the crop ends from the ingot, rejected as not being good enough for a rail, are so rolled.

We have never rolled any concrete reinforcing bars, and the Longmead Iron Co. has no interest in the matter, but we have been solicited to roll such bars, with the statement that any material unsuitable for other purposes could be used. We are asking, therefore, as a matter of interest and information, why bars rolled from rails should be so condemned by Mr. Stern. Having suffered in our line of manufacture from the prejudice created by unauthorized assertion, it would seem to me that such attacks on any line of material should not be published without reasons being given, and without the person making such attacks, whether manufacturer, engineer, architect or what not, giving such record of his experience as will enable those reading his communication to judge of his experience and knowledge of the matter.

LEWIS N. LUKENS,
President, Longmead Iron Co.

Conshohocken, Penn., Feb. 19, 1912.

Sir—It would be of considerable interest to certain members of the engineering profession interested in the design of reinforced concrete, and who may perhaps be termed "Progressives," if E. W. Stern would state fully in another letter the reasons for the sweeping conclusion expressed in his letter on p. 305 of your issue of Feb. 15, to the effect that it is a very dangerous concession to commercial interests to permit the use of reinforcing bars rolled from T-rails, as is permitted in the recently revised building code of the city of Cleveland, Ohio. The writer understands that the city of Cleveland availed itself of considerable expert engineering advice in revising the section of its building code relating to reinforced concrete.

PAUL SHELDON.

Hartford, Conn., Feb. 21, 1912.

Sir—We note the letter from E. W. Stern on the subject of re-rolled rails for reinforcing steel. While the letter in question consists merely of an expression of the writer's personal opinion, unsupported in the slightest degree by facts, figures or fancies, we feel that the impression it might possibly leave upon your readers would not be fair to the re-rolled steel industry if the subject is left in its present incomplete state.

A dogmatic statement, such as Mr. Stern has made, is to say the least, an unusual method of argument. If there is no question in the minds of your readers that the opinion expressed is correct, if the bald statement made is a universally accepted axiom in the concrete industry, it would seem that the letter was rather a gratuitious offering, made with no particular object.

If, on the other hand, the statements made are merely the writer's personal opinion on a disputed point, we do not consider the letter a particularly forcible nor a really fair contribution on the subject of reinforcing. We believe that a statement as strongly voiced as this,

should be accompanied by facts and figures in support of his conclusions, or if facts are not available, at least by the theory upon which the opinion so arrogantly stated is founded and arrived at.

Mr. Stern will confer a substantial favor upon the concrete fraternity if he will enlarge somewhat upon the subject which he attempts so summarily to definitely settle.

L. W. BARNETTE,
Secy., Franklin Steel Co.

Franklin, Penn., Feb. 24, 1912.

[The above letters were submitted to Mr. Stern, and he has informed us that inasmuch as there is apt to be a good deal of correspondence on the subject, he would prefer to prepare his answer later in the discussion.—ED.]

Using an Inclined Stick or Tube to Prevent Standpipe Failures from Ice

Sir—Referring to the standpipe failure recorded in your issue of Feb. 1, it may be of interest to note a simple device for preventing the bursting of vessels by ice. All you have to do is to place a stick in the vessel in a slanting direction, when the ice crawls up it and the pressure is relieved. I take it that the explanation is that with a horizontal surface there is nothing to enable the ice to yield more in one direction than another, but the introduction of the stick creates a point of weakness.

This works all right for small vessels such as filters, but would require some modification for the large area of a standpipe. The arrangement might be a zigzag tube or tubes with a small flame, such as a kerosene burner, at bottom just sufficient to create a point of weakness in the ice field.

F. G. ROBERTSON.

13 Dartmouth St., London, S. W.

[We leave to our readers the application of this suggestion to water works standpipes 20 to 30 ft. in diameter and 100 to 150 ft. or more in height, in climates where the thermometer is sometimes —10° F. for days at a time and may occasionally go to —20° F. or lower. —ED.]

A Rainfall of 55 In. per Month

Sir—I inclose herewith a statement of our rainfall at Hilo, as published by the *Tribune* of this place.

The rainfall comes mostly at night, and the precipitation is rapid. March, 1902, with 55 in., is attractive! Also January, 1898, with 41½ in., and March, of the same year, with 50 in. The heaviest rainfall is at 3000 ft. elevation, on "Mauna Kea," a few miles west of Hilo. I think this is the wettest city in the U. S.

"X Y Z" (C. E.)

Hilo, Hawaii, Jan. 31, 1912.

TWENTY-ONE YEARS RAINFALL (INCHES) AT HILO, HAWAII

	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900
Jan.	.....	12.48	1.71	16.81	3.22	3.02	3.59	41.51*	4.78	2.72
Feb.	.....	11.29	9.33	25.71	2.10	12.00	11.20	6.94	8.80	6.14
Mar.	10.10	10.89	15.05	17.11	6.23	13.42	12.69	49.75*	22.80	5.58
Apr.	10.68	2.64	20.74	17.25	28.42	18.05	3.11	6.95	16.51	5.47
May.	5.07	3.21	10.73	1.87	8.63	13.85	6.43	7.32	19.61	16.41
June.	5.71	8.24	8.00	4.58	6.08	7.57	3.46	4.30	7.70	3.79
July.	9.75	10.48	7.17	9.35	7.38	6.84	6.42	10.32	5.42	8.73
Aug.	12.34	10.73	6.03	3.64	14.71	19.63	9.42	6.83	15.31	14.87
Sept.	14.92	9.35	5.20	5.66	19.67	10.83	5.38	8.67	8.38	6.94
Oct.	25.27	10.97	8.35	7.50	9.38	7.05	9.20	9.41	22.04	19.37
Nov.	10.46	6.98	14.37	13.26	12.70	2.68	16.59	8.25	4.58	15.44
Dec.	25.42	11.83	6.73	17.78	12.51	5.34	9.76	2.04	0.83	5.65
	129.72	109.09	113.59	139.94	121.03	120.28	97.25	162.22	134.76	111.08

	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911
Jan.	9.53	2.63	3.99	22.87	0.78	4.91	4.63	7.84	6.04	16.10	15.76
Feb.	7.32	3.56	9.18	11.17	5.93	1.89	12.39	22.30	9.69	2.48	15.61
Mar.	26.88	55.16*	3.55	0.90	6.04	1.63	12.68	5.43	27.98	13.17	12.13
Apr.	12.85	9.48	17.69	22.88	5.69	7.72	6.58	15.69	6.20	9.35	15.23
May.	3.53	13.35	6.74	7.80	6.89	9.45	5.90	7.87	11.52	12.20	15.04
June.	3.45	3.09	4.90	8.73	7.80	6.01	8.50	6.01	5.85	11.55	10.46
July.	4.76	18.22	20.13	11.42	8.31	12.31	9.43	6.24	13.18	10.43	
Aug.	6.85	18.39	7.32	11.73	11.53	19.51	31.87	10.56	5.18	16.11	
Sept.	4.69	10.18	13.46	8.49	19.06	6.54	25.06	14.29	8.03	5.25	
Oct.	12.10	12.37	12.37	3.88	10.08	4.12	19.94	9.83	8.29	7.96	
Nov.	36.09	10.36	14.06	5.19	26.03	15.55	10.88	5.58	3.77	10.87	
Dec.	12.99	15.40	6.10	4.50	13.49	9.98	4.51	14.37	11.49	14.12	
	140.85	166.79	119.49	122.56	121.63	99.62	152.37	126.01	117.22	129.59	84.23

*Unusual. †Actual total for the whole year, 147 in.

Notes and Queries

The list of names of men connected with the Cambridge Subway work (see article by L. E. Moore, Eng. News, Feb. 1, 1912), should include the following: J. R. Worcester, Consulting Engineer; Peabody & Stearns, Consulting Architects; H. F. Sawtelle, Designing Engineer. The construction of the concrete floor in the center of Cambridge Bridge, and the erection of the elevated structure from the east end of the bridge to the west portal of the Beacon Hill Tunnel, were in charge of C. T. Fernald, First Assistant Engineer, Boston Elevated Railway Co.

A Vibrating Reed Tachometer, or revolution counter, was described in the "American Machinist," of Feb. 22, 1912. The mechanism of the instrument consists of a row of flat steel springs, or reeds, each about 3 mm. in width and of progressively varying lengths, like the reeds of a mouth-organ. These are firmly attached at one end to the base of the instrument, with their free ends flush with the dial. The dial has a wide slot diametrally across it, and the ends of the reeds form a line down the middle of the slot. A short length of the free end of each reed is bent over at right angles and enameled white, so that the appearance is that of a line of square white dots.

In use, the instrument is rigidly attached to the base or cover of the machine of which the revolutions are to be measured. Some one of the reeds, which may have a vibration rate corresponding with the rate of revolution, will vibrate through a considerable amplitude and will appear like a short transverse streak across the line of white dots formed by the other reeds. Graduations along the edges of the slot in the dial give the number of revolutions per minute corresponding with the vibration rates of the reeds.

This device is made by Siemens & Halske, Berlin, Germany, and is being marketed in this country by James G. Biddle, of Philadelphia, Penn. It is known as the Frahm vibrating tachometer. The makers recommend it for speeds of from 900 to 8000 r.p.m. One instrument, as shown in an illustration, has graduations from 1600 to 2400 r.p.m. with one reed for each 25 r.p.m. throughout this range.

A New Rock-Drill with air-cushioned piston has been brought out by the McKiernan-Terry Drill Co., of 115 Broadway, New York City. The long piston has a central longitudinal bore into which fits the stem of the rifle-bar, seated in the back cylinder-head. The active space of the cylinder, being the annular space around the rifle-bar, communicates with the hollow of the piston by a port drilled through the rifle-bar, but a check-valve at the inner end of this port prevents the egress of air from this hollow. Thus, on the upstroke the charge of air contained in the bore of the piston is trapped and therefore undergoes compression as the piston moves up; this compression brings the piston to rest before it can strike the back head, and also furnishes a strong recoil to start the piston on its downstroke. Simultaneously the main valve admits fresh compressed air to the active cylinder space, so that during the downstroke the full area of the piston is under pressure. As the air in the interior of the piston expands, it is kept up to the full cylinder pressure by air passing in through the port drilled in the rifle-bar stem; this action makes up for any leakage out of the piston-bore during the high compression of the upstroke.

This new drill, called "Wizard Drill," is claimed to deliver a much harder blow than ordinary rock-drills, and thereby to drill faster. Trials made in comparison with other drills seem to have shown that a "Wizard Drill" will do the work of a larger-size rock-drill of other type. An article in "The Engineering and Mining Journal," of Feb. 24, 1912, gives a description and quotes several test results, showing drilling speeds up to 20 ft. per hr. in Fordham gneiss and nearly 6 ft. per hr. in granite.

Dam Inspection in Pennsylvania*

By Farley Gannett†

Although dams on the major streams of Pennsylvania must, under an act of the legislature, passed in 1907, receive the approval of the State Water Supply Commission before they can be built, such structures as that at Austin were apparently subject to no state direction. The supervision of methods of construction and of operation subsequent to completion has been in the hands of no state functionary, however large the dam or whatever the stream it may be erected upon. The failure of the Austin dam has had the effect of creating an active support for the Commission both public and official, in its action, beyond what has been accepted as its prescribed duties, in extending a careful supervision over the design, construction and operation of dams throughout the Commonwealth.

The Commission was promptly represented at Austin, its representative being (so far as is known) the first member of the engineering profession at the dam, the day following the disaster. Subsequently each member of the Commission visited the scene, and careful studies were made of the conditions leading up to the dam failure, the result being that a thorough investigation has been ordered to determine by means of test pits and excavations, the exact nature of the foundations and underlying strata. Furthermore the Commission has decided to examine all dams under construction and in use, and, with the approval of Governor Tener, to maintain an oversight over such structures, pending more definite legislation on this subject.

As a direct result of the failure of the Austin dam, numerous complaints were received by the Commission, or by the Governor and referred to the Commission, requesting examinations to be made of existing dams which were feared to be weak and in danger of failure. We have examined numerous such structures, both completed and under construction, and several instances have been found of poor design and construction. One not familiar with these facts would hardly believe it possible that some of the structures could have been designed and built, and far less than they should have stood. A few instances may be interesting.

Defective Dams

One example is a large earth dam with concrete core wall, approximately 45 ft. high and 700 to 800 ft. long. It appears that when work on this structure was started, the corewall was finished to its final dimensions, and the earth fill partly placed on the upstream side, while on the downstream side hardly any material was in place. The only means of exit for the water from a drainage area of 10 to 12 sq.mi. was through two 36-in. pipes. The natural result followed when a rainfall caused a runoff greater than the capacity of the pipes. The reservoir filled to give a pressure on the corewall which it was not designed to withstand unaided, and the whole thing gave way.

A concrete structure about 25 ft. high, 48 in. wide on top, and 336 ft. long, impounds a lake nearly a mile long, at the head of a rather populous valley. The dam was found to be leaking at many vertical joints, at one point the water coming through at a pressure which forced it out in a little stream several inches from the face of the dam. There were also cracks in the horizontal joints and imperfections in the concrete due to careless mixing and placing. The surface of the ground below the dam was soft and soggy due to these leaks, and perhaps to leakage under it. The design of this structure is also at fault. The owners have been directed to empty the reservoir and to prepare plans for reinforcing the dam.

Another example of an engineering point which the Commission has remedied in the design of a new earth-fill dam with concrete corewall, was the omission of a puddle cutoff wall, which omission would have enabled water to find an entrance through a gravel stratum 4 to 5 ft. thick under a considerable portion of the upstream side of the dam above the corewall.

An earth dam with concrete corewall, 16 ft. in height and 350 ft. long, was being built for additional storage by a water company. This structure is to impound 4,000,000 gallons of water in a little valley immediately above a small settlement. The only plan which the builders had was entitled "a preliminary sketch," by the engineer who made it. It appears that this engineer had not been employed other than for this preliminary sketch and even that has been modified in essential particulars; for example, it was found that the upstream face was being given a slope of 1 on 2 instead of 1 on 3 as called for by the plan, the corewall, instead of being 24 in. thick, was being made 12 to 14 in. thick, the blowoff pipe was changed from 8 to 6 in., etc. The forms on the downstream side of the corewall consisted of a dry rubble wall. The downstream portion of the embankment was placed without preparing the bottom in any way. The spillway was a section of the dam just like any other except that it was to be paved with riprap. It is needless to say that this work has been stopped and that the water company has been instructed to engage an engineer, [illegible]ving him until the work is complete[illegible] and to submit plans for the completion of the structure.

The case of a concrete structure built on an old earth dam offers some novel conditions. This dam was built for a water company for storage, and was originally an earth-fill structure with a dry rubble wall 3 ft. to 5 ft. thick on its upper face. The fill was over 60 ft. wide on top, 14 ft. high and 210 ft. long. To increase the storage a concrete structure was erected on the stone wall and earth fill. A trench 4½ ft. wide and 3 ft. deep was dug below the wall down to gravel on one side of the valley and shale on the other, but no further borings or excavations were made. Concrete was placed in this trench and extended up the face of the old wall, 3 ft. thick and 13 ft. above the original top of dam. The upstream face is vertical, top width 4 ft., with batter on downstream face, giving a width on the level of the old top of dam 7 ft. 2 in. Reinforcement of ¾-in. steel bars, horizontal and vertical, 3 ft. c. to c. in both directions was placed; this also served to tie the concrete in the rubble wall. The oueside base of the downstream slope rests on the earth fill.

The dam was found to be leaking in three places between the base of the concrete and the old fill. The largest leak had washed a channel for itself through the fill. These leaks may come up under the concrete toe and thence follow the rubble wall, emerging under the base of the concrete, or may come through settlement cracks in the concrete. The reservoir has been ordered emptied so that the cause of the leaks can be determined and repairs made.

*Abstract of a paper printed in the "Journal of the Engineers' Society of Pennsylvania," January, 1912, under the title "Remarks on the Austin Dam Failure."

†Engineer to Water Supply Commission of Pennsylvania.

Brick Paving without Curbs, for country roads, has been used to a limited extent, the purpose being to reduce the cost of a narrow strip of brick paving on an ordinary dirt road, where no concrete base is used. To prevent the bricks at the sides of the paved roadway from separating from the others, when not supported by a curb, bricks of special form have been tried. These are slightly narrower at the middle than at the ends, so that they interlock or dovetail together, and those at the edges cannot separate from the others. The transverse joints in the pavement, therefore, are not straight, but irregular or wavy. Of course, the bricks are laid to break joint. It is claimed, however, that this interlocking is unnecessary, as ordinary bricks with proper joint filler will be held together so firmly that they cannot separate, even along the edges of the pavement. The construction with special brick, also, is said to have been only partially successful, and in general a marginal curb is considered desirable. Its use in Ohio was mentioned by W. T. Blackburn at the annual meeting of the Illinois Society of Engineers and Surveyors.

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Engineering News

Increasing the Capacity of the New York Subway

Elsewhere in this issue we describe some of the improvements in the operating equipment of the New York Subway, which have effected a remarkable increase in its traffic capacity.

The subway was originally planned for a maximum traffic capacity of 400,000 passengers per day. This traffic was considered by many a mere possibility of the remote future; and there were plenty of critics of high standing who declared that the subway engineers were mere sanguine dreamers to expect that such crowds would ever seek an underground road. All through the dozen and more years when underground rapid transit was merely a project as well as the later years while construction was going on, there were many business men and even engineers of high reputation who constantly declared that the underground lines would never have traffic enough to make them pay.

Experience has demonstrated that the critics were wholly mistaken. The growth of subway traffic has outrun the expectations of the most sanguine. In 1905, the first full year of operation, the average daily traffic of the subway was about 250,000 passengers per day. Two years later, in 1907, it was above 450,000, or well beyond the maximum capacity for which it was designed. In four years more, by 1911, it increased to 758,093 as an average of the entire year, and during the winter season the travel on every week day approaches near the million mark, and on any special occasion it runs far above this.

The principal change by which the subway traffic capacity has been raised to more than double that originally planned, has been the running of much longer trains, of ten cars instead of the five-car trains originally used; but trains are also run at shorter intervals during rush hours. These changes have necessitated longer station platforms, better brakes, couplers and signals, center-side car doors, and many other new features. While making the changes necessary to handle the crowds which surge into the subway stations during the rush hours, the operating company has added several features to increase the safety of travel.

The several pieces of new equipment described elsewhere are important achievements in railroading and all those responsible for the designs are to be congratulated on the results secured.

The gain in capacity of the subway system produced by decreasing the time interval between trains, however, has reduced the flexibility of operation in the rush hours. The system works like a huge chain belt with very little play between the links, the play representing all the flexibility left. The slightest delay to any train produces delay to every train following, and even trivial causes may stop the movement of trains from end to end of the line.

It is not possible further to increase the subway's capacity by further increases in length of trains, for already cars near the station entrances are crowded while cars near the ends of the train have vacant seats. Neither can trains be run more frequently with safety or advantage. Further increase of traffic must be cared for by new subways.

A High Wind Velocity Record at New York City

Wide publicity has been given to the announcement that the maximum wind velocity recorded by the official Weather Bureau instruments in New York City, during the storm which occurred on the morning of Feb. 22, was 120 miles per hour.

Accurate records of maximum wind velocities and pressures are of great importance to engineers and we doubt not many engineers resident in and near New York have been led to question the accuracy of the above record. Severe though the gale undoubtedly was, if it had attained any such velocity as 120 miles per hour, producing pressures in excess of 50 lb. per sq.in., on exposed surfaces, enormous destruction would have been wrought all about New York and its suburbs.

It is well to put on record therefore, that while the Weather Bureau anemometer on top of the Whitehall Building did record the passage of two miles of wind in 60 seconds at the height of the storm, and while this statement was furnished to the press, in accordance with the Weather Bureau rules, the true velocity of the wind was much less than the velocity indicated by the anemometer.

The Weather Bureau formula for reducing indicated wind velocity to true velocity, applicable to its standard Robinson anemometer, is

$$Log.\ V = 0.509 + 0.9012\ log\ v.$$

In this equation V is the actual velocity of the wind in miles per hour and v is the lineal velocity, also in miles per hour, of the centers of the whirling cups.

Applying this formula, the maximum wind velocity in the recent storm appears

to have been about 90 miles per hour instead of 120 miles.

It is questionable, however, whether even this velocity is a true record of the actual average velocity attained by the wind current moving over the surface of the earth. The effects upon the anemometer record of obstructions to the wind current in the vicinity must be borne in mind. The Weather Bureau in New York City is located on the roof of a high office building near the southern extremity of Manhattan Island. A southwest gale, sweeping across the waters of New York Harbor with practically no obstruction, strikes the great mass of high buildings grouped on the lower end of Manhattan Island. It is conceivable that these buildings act upon the flowing river of air very much like a submerged dam placed in the bottom of a river, and increase the velocity of the wind for some distance above the obstruction so that the velocity is considerably higher than would be recorded if the anemometer were placed out in the middle of a broad plain or on a broad water surface. It is well known how a moderately high wind will produce a current around the exposed corner of a high building against which it is almost impossible to stand.

The Prospect for a Federal Law Governing Employers' Liability

If is always dangerous to prophesy concerning the course of legislation in Congress. Unless all signs fail, however, there would seem every reason to believe that before the adjournment of the present Congress a law will be enacted providing a new system for the compensation of railway employees injured or killed in the course of their employment.

A Commission to investigate the matter of employers' liability and workmen's compensation, appointed in accordance with a joint resolution of Congress approved June 25, 1910, has just made a report which was transmitted to Congress with a special message by President Taft on Feb. 20.

The Commission which made the investigation and has drafted a bill is made up of Senator Sutherland, of Utah; Senator Chamberlain, of Oregon; Representative Grantley, of Georgia; Representative Moon, of Pennsylvania; W. C. Brown, President of the New York Central R.R., and D. L. Cease, Editor of *The Railroad Trainman.*

According to the summary of the bill given in President Taft's message, it provides compensation for accidental injuries to railway employees on all interstate railways without regard to whether the accident resulting in the injury was in any degree due to the injured person's contributory negligence and without any of the other limitations which have in common law relieved the employer of liability. The only cases where no compensation is to be allowed is where the accident is the result of wilful intention or where the injured person was hurt as a result of his intoxication while on duty. The amount of compensation is to be proportioned to the wages received at the time the injury occurred and in case of death, to the number dependent on the person injured. The fees which may be paid to attorneys are specifically limited and the compensation is to be exclusive of all other damages.

So far as the legal status of the proposed act is concerned, the Commission has very carefully investigated it and President Taft himself gives it chief attention in his message to Congress. His opinion that the act is constitutional will have great weight.

It is unnecessary to review the arguments in favor of such legislation. ENGINEERING NEWS was, in fact, one of the very first American journals to call general attention to the need for radical reform in employers' liability laws along the lines which have been followed by all other industrial nations of the world. That the new system will be liable to grave abuses is doubtless true; but no one who has given candid and unprejudiced study to the whole matter can believe that these abuses will be anything like as great as the evils of the present situation, which are rapidly growing more and more unendurable.

The Commission estimates that the enactment of the new law will add about 25% to the present expense incurred by the railways on account of injuries to employees. It will, however, add far larger percentages than this to the amount received by railway employees and their dependents on account of accidents, because a large part of the money spent by the railway companies at present on account of accidents goes to pay the expenses of litigation and for premiums to insurance companies.

If the Commission's estimate be accurate, it is doubtful whether there is any other direction in which an equal amount could be spent by the railway companies with greater resultant benefits.

As noted above, the bill has been drafted by a Commission on which railway officers and railway employees, as well as members of Congress, were represented. The bill received the strong endorsement of President Taft, who has urged upon Congress its speedy enactment into law. No political party or group in the House or the Senate can make any capital for use in the coming national election by opposing the bill, and it is probable that the majority in the House and the majority in the Senate will be equally eager to gain what credit they can by giving the bill prompt passage. If this prediction should prove correct and the bill should become law, it will undoubtedly have a very great influence in bringing about the enactment of similar laws in the various state legislatures which will govern compensation to employees of railways which do not pass beyond state boundaries, and will also probably be extended to employees of other public utility companies and manufacturing concerns.

State Highway Construction in New York

To a far greater extent than any other state in the Union, New York has embarked on the policy of state highway construction. Five years ago a state bond issue of $50,000,000 was authorized to be expended in the construction of improved highways. After various difficulties due to changes in the state government, the work was placed in charge of a state highway commission. It was hoped that this would put the management of the work on a permanent basis and avoid the sweeping changes due to political overturns. This hope was not realized, however, for last summer the law was again radically changed and a new highway commission made up of state officers was placed in control. The report of this commission, presented to the Legislature last week, summarizes the work done up to date under the state bond issue.

The first and most striking feature in the report is that only about $1,000,000 out of the $50,000,000 bond issue remains unspent, and whereas nearly 12,000 miles of improved highways were laid out originally to be improved by the state with this $50,000,000, only 3764 miles have been completed or placed under contract, leaving 8130 miles yet to be constructed.

We find nowhere in the report any direct statement of the average cost per mile for the roads thus far built; but the above figures would indicate that the cost has certainly exceeded $13,000 per mile.

There remain, according to the commission's statement, 8130 miles of road yet to be constructed to complete the system originally planned, and the commission recommends an additional state bond issue of approximately $50,000,000 to be applied to this purpose. Inasmuch as the $50,000,000 already expended has built less than 4000 miles of road, it is far from clear how an additional state bond issue of $50,000,000 can build more than double this mileage. Perhaps it is the idea of the commission that a large proportion of the cost of building the remaining 8000 odd miles should be borne by the counties themselves, but the final burden to the taxpayer remains the same whether his assessments are paid to the county or to the state.

To a road engineer, doubtless the most interesting feature of the highway com-

mission's report is that dealing with the types of road construction. The new commission is made up of three state officials, C. Gordon Reel, State Superintendent of Highways; John A. Bensel, State Engineer and Surveyor, and Duncan W. Peck, Superintendent of Public Works. As is well known, this commission, and especially its most active member, State Engineer Bensel, is actively hostile to the policy and practice of the former state highway commission. Great interest has been felt, therefore, to see what the new commission would propose to better the work of its predecessor. The section in the report entitled "Types of Construction" throws some light on this matter. We quote as follows:

> The Commission desires to emphasize the fact that the work completed during the construction season of 1911 in no way reflects the policy of the present Commission as it is intended to change the past method of construction as rapidly as possible whenever it has been found inadequate and unwise.
>
> The former Commission adopted a form of construction known as "bituminous macadam." It has been fully demonstrated that this class of construction has not given results such as would justify the increased cost. This Commission believes that it is impossible to obtain satisfactory results in highway construction until more attention is given to subsoil drainage, properly designed and constructed foundation, and a wearing course in which there is a more complete physical and chemical union of the units composing it; one which acts as a wearing course only and not constructed so that its main function is to assist an improperly drained and poorly designed foundation.
>
> Having these factors in view it seems wise, wherever possible, to construct a foundation of concrete and to cover this with a thin wearing course composed of bituminous material and screenings of sand which is economical in first cost and easily and cheaply renewed. The foundation of a road, so constructed, is good for all time and the wearing course serves the purpose of carrying all classes of traffic without rubbing, raveling or raising a dust.
>
> While the concrete-bituminous type of highway will probably be most generally adopted, owing to local conditions, the supply of proper material, and the fact that the traffic on some of the outlying highways does not, as yet, warrant the adoption of this class of construction, other classes and types of construction will be used. The problem of mixing clay, or ordinary soil, with bituminous material seems to have been solved, and it is intended to thoroughly try out this class of construction since in many localities it will furnish an economical substitute for materials which have to be imported at a high cost for freight and hauling. This Commission believes that this latter factor will materially reduce the cost of construction.
>
> The cheaper forms of construction which have been adopted consist of a top bituminous treatment of gravel and hard-pan soils and the placing of a bituminous wearing surface on well-constructed water-bound macadam roads.

This is certainly radical doctrine enough to suit the most progressive. It is much to be regretted that the commission did not enrich its report with figures giving the comparative cost of construction of bituminous macadam laid according to the latest and best specifications, and the type of concrete pavement with bituminous wearing coat which it proposes in its place.

Still more novel is the commission's proposition to improve country roads where cheaper construction is necessary "by mixing clay or ordinary soil with bituminous materials." If it is possible to build a low-cost good road by mixing tar or asphaltum oils with the clay, sand, gravel or mud of the ordinary dirt road, the news is important, if true, and it *is* news to us at least. So far as generally recorded experience goes, it is pretty well known that the so called "oiled highway" in which California asphaltum oils were mixed with ordinary earth has not shown any such durability as was claimed for it when a considerable mileage was built in this way in southern California a dozen years or so ago.

Another very interesting paragraph of the commission's report is worth quoting in full as follows:

> So far as is practical, a five-year maintenance bond is to be required on all the best classes of construction. This will have a tendency not only to reduce the future maintenance cost, but will also cause more careful construction.

As our readers know, the question as to the wisdom of exacting a bond for maintenance from street-paving contractors has been pretty well threshed out by engineers and the consensus of opinion is strongly against the requirement of such a bond. If this is true on city street pavements made of such permanent materials as stone block, brick, asphalt, etc., how about requiring a five-year maintenance bond on the comparatively perishable materials which are necessarily used in construction of country roads? The commission apparently intends to let contracts this coming season for its proposed concrete bituminous-top highway. How many times will the contractor have to renew that bituminous top surface during the period of his five-year maintenance bond and how much will he have to add to his bid for construction on this account? The answers to these questions will be exceedingly interesting to engineers.

We wish the section of the report which relates to New York's present expenditure for maintenance of its new state roads could be carefully and intelligently studied by the agitators who are working for enormous bond issues to be spent on good road construction and who are wholly overlooking the necessary cost of maintaining such roads and the limits of the ability of the various communities to stand the necessary taxation. The fallacy which continually crops up in "good road" literature is that a good road once built requires comparatively little expenditure for its maintenance. The people who are voting millions of dollars in bonds to run 10, 20, 30 or 40 years for state and county highway construction do not realize that they will have to pay not only the interest on these bonds and the sinking-fund charges for their eventual payment, but also a very large sum for maintenance. In 1910, New York had 2123 miles of new state roads to maintain, and it expended on maintenance alone on these roads an average of $1001 per mile. During 1911, the maintenance work was cut down so that only $1,000,000 was spent, but the result is that the roads are now badly worn and require immediate attention to save them from destruction. The commission says there are 200 miles of roads which need resurfacing and about 1000 miles which need a light top course of fine stone or gravel and oil treatment. The commission requests an appropriation of nearly $3,000,000 for maintenance alone during the year to be expended on 3151 miles of road, or an average cost per mile of $926.

It is little short of childish to argue, as has been done, that the reason for the heavy cost of road maintenance in the state of New York is because the work of construction was not well done in the past or because improper methods of construction were adopted. Whatever the faults and failings may have been on past highway work in New York, the fact is that the experience of New York in high cost of maintenance of good roads is the experience of all other states which have embarked on good road construction and of European countries as well.

The good road enthusiasts, who think that it costs nothing to maintain a good road once built, or who expect that present expenditures on road maintenance will be reduced by macadamizing all highways, should be interested to know that in England, where practically all public highways are macadamized, the cost of road maintenance in the last year for which figures have been published, was in the neighborhood of $65,000,000.

As every highway engineer knows, the cost of road maintenance everywhere has been doubled and quadrupled by the coming of the motor vehicle; and the end is not yet. If conditions are bad in England, they are far worse here, where larger means and greater extravagance make the number of automobiles in use far greater than on English highways.

Further than this, English statesmen have been wise enough to see the necessity of limiting the burden placed on their improved roads and a law has been in force there for several years limiting the loads which may be carried on motor trucks and the speed at which they may be run.

There is no more important passage in the New York commission's report before us than that in which it urges that laws should be enacted by the Legislature fix-

ing limits of loads and speeds for motor vehicles in New York. The commission says that loads are being hauled on motor trucks in various parts of the state which no road can withstand and that instance after instance can be cited where sections of the state highways have been practically destroyed by this abuse. Regular freight lines of motor trucks have been established between large towns and the only limit of loading of these trucks is the limit which the vehicle itself can carry. Until some barrier is erected against the destruction of roads by these means, to expend the taxpayers' money on good road construction and maintenance is very much like pouring water into a sieve.

A Plea for Common Sense in State Control of Sewage Disposal

Four of the most eminent consulting sanitary engineers of the United States have united as one man to hold, in effect, that the Pennsylvania Department of Health assumed an unwarrantably radical if not a quixotic position when it ordered the city of Pittsburg to submit plans for separating its sewage from its storm-water drainage and for purifying the sewage to a drinking-water standard before discharging it into the Ohio River. (See abstracts of Pittsburg sewage disposal reports elsewhere in this issue).

There is reason to believe that the city authorities of Pittsburg will adopt the recommendations of these engineers, as has already been done by one of its engineer-officials, and that thus the Pennsylvania Department of Health will have to recede from its radical position or else enter into a legal conflict with the second-largest city of the state. If it takes the latter course it will doubtless have more than one city to fight, for the department has issued scores of orders calling on other cities and boroughs to file plans for sewage-treatment works.

Even Philadelphia is under such orders, and, judging from the experiments it has made on sewage treatment, has interpreted the orders to mean purification of its sewage to a high standard even though the Delaware River, an arm of the sea, is at its doors. Already the city of Meadville has considered the matter of contesting the legality of like orders issued against it, but having secured an extension of time for filing its plans it has decided first to try to get relief from the state legislature when it meets in 1913.

The Pittsburg and Meadville authorities urge that they could not build the works evidently demanded by the State Department of Health without exceeding their debt limit, and thus breaking one law in order to obey another.

The same condition, we understand, confronts other Pennsylvania cities under these orders. In fact, it was early recognized that the Pennsylvania sewage-purification campaign created a serious financial problem. If we remember rightly, a bill was introduced in the Pennsylvania Legislature a few years ago providing for state aid to such municipalities as were financially unable to carry out the orders of the State Health Department, and authorizing the State Department of Health to do the necessary engineering work.

Without state financial aid there appears to be only two ways of providing funds for the wholesale sewage purification on which the Pennsylvania State Department of Health has set its heart and for which it is risking its future usefulness: either municipalities must be permitted to issue sewage works bonds in excess of their debt limit or they must farm out their sewage and sewage disposal systems to franchise companies.

We have been told by a Pennsylvania engineer who is in a position to be well informed that private interests kindly stand ready to step into the breach and provide sewage purification on either a franchise or yearly rental plan—the latter has already been done at Reading. We cannot at this time discuss the wisdom of farming out such sanitary works, further than to say that sewerage systems and sewage-purification plants are about the last class of municipal undertakings which any hard-pressed city would turn over to a private company, so that such propositions in Pennsylvania show the extremes toward which the municipalities of the state are being pushed by its central health department.

In passing, another aspect of the Pennsylvania sewage-disposal situation may be mentioned. We have never believed that Philadelphia, Pittsburg and other municipalities would ever actually carry out the plans for elaborate sewage-purification works demanded by the State Department of Health unless through a direct or tacit alliance between the city authorities and political contractors. It has been through just such an alliance as this that unnecessarily large or extravagantly expensive public works have been carried out at Philadelphia, until now, if the local press of that city can be trusted, it is in a serious financial condition.

The Pittsburg authorities, we are glad to see, have put the interests of the city at large above those of the political and contracting interests. With a reform mayor and director of public works at the head of the government of Philadelphia that city may also be expected to come out flat-footedly against any heavy outlays for sewage purification, unless recommended by disinterested sewage-disposal experts after careful investigation.

In justice to the State Department of Health of Pennsylvania, we take pleasure in saying that we do not for a moment believe that it is in alliance with either sewage franchise seekers or political contractors. But it appears to have been working to the advantage of both, besides building up, or trying to build up, a system of absolute control of local sewage disposal unparalleled elsewhere in the world. This, combined with the army of engineers and medical health officers in the employ or under the control of the Department, makes one shudder to think of the force it may become for political corruption whenever the present head of the Department is replaced by a typical political apointee.

We believe that the numerous Pennsylvania sewage-purification orders have been issued with the single-minded purpose of protecting the health of the people of the state, and that the radical and quixotic character of some of them has been due to a misconception of the sewage-disposal problem as a whole; to superficial studies of local conditions prior to the issuing of orders which put municipalities to a large expense for making plans that may never be needed; to a general disregard of other needs than sewage disposal in a given city, some of which may more vitally affect health than does sewage disposal in certain cases; and to a failure to recognize the fact that the rights of the city affected by a sewage-disposal order deserve consideration equally with those of the communities or individuals for whose benefit the orders are issued.

It is scarcely necessary to enlarge upon any of these points, because they are all made so evident by the Pittsburg reports, which we have already mentioned as appearing in abstract elsewhere in this issue.

Special attention may be called, however, to the apparent intention of the Department to force a population of a million to attempt the removal of disease germs from their sewage at an expense of fifty million dollars (we use round numbers) in order to afford a questionable protection to the water supplies of a hundred thousand people, which supplies perhaps represent an investment of three million dollars. These water supplies are not taken directly from the river which receives the sewage in question, and could be rendered practically sterile at a slight annual expense, or could be replaced by supplies from other sources at a small fraction of the cost of separating and purifying the sewage of Pittsburg and vicinity.

If it be urged that the city of Pittsburg has not been ordered to spend a dollar for sewage purification, but merely to study the problem and submit plans to the State Department of Health, then it may be asked what warrant the Department had for compelling the city to go to so much trouble and expense when, as

Messrs. Hazen, Whipple, Stearns and Eddy all agree, there is no occasion whatever for any radical changes in sewage disposal at Pittsburg?

The hundred pages of typewritten matter comprising the "permits" under the conditions of which sewage-purification plans were demanded contained little, indeed, to show either that sewage purification could be rightly demanded or that a thorough-going engineering study of the prevailing conditions had been made by the Department.

The Pennsylvania Department of Health, although headed by a man of unusual scientific attainments and having a large engineering force, seems to have joined blindly in what may be termed the doctors' or physicians' campaign against the discharge of untreated sewage into streams, with little or no regard to the local physical and financial conditions, which may profoundly affect each case. Fortunately, the Pennsylvania department has not yet gone far beyond calling for plans for sewage purification and, of course, it will never make itself so ridiculous as to issue a blanket order for all sewered municipalities to put in either septic tanks or filter beds, as did the Minnesota Board of Health some years ago.

The Pennsylvania Department has aligned itself in part, but not yet wholly, with the principles of "The New Public Health," so well set forth by Dr. H. W. Hill, elsewhere in this issue. That is, it seeks to control the causes which spread disease, instead of campaigning against mere filth or odors or offenses to the eye; but, if its Pittsburg sewage-disposal order is a fair sample, it needs to temper the ideal theories of the scientific laboratory with the practical experience of the engineer and the financier, and gain a conception of relative needs and values. We do not mean by this that money is above life and health, but rather that when there are so many more demands for direct and indirect health-protective work than our cities seem to be able to meet, none of them should be contented with only a cent's worth of health protection for a dollar of outlay, when, if the money were wisely used, the return would be dollar for dollar.

Two important suggestions not already mentioned may be offered before we close. The first one is that the state boards and departments of health throughout the country, in whose hands additional powers over water supplies and sewage disposal are being placed every year, should use those powers with the utmost caution, and only in accordance with the soundest engineering advice the country affords. We use engineering here in a sufficiently broad sense to include all the teachings of bacteriology, prontozoalogy, chemistry, medicine and epidemiology, as regards the relation between sewage disposal, water supply and disease. Few state departments of health come near this standard as yet, while some of them are still in that blissfully ignorant stage which regards the septic tank as the one and only thing needful to prevent either a local nuisance or the spread of typhoid through sewage.

Our other suggestion is that if state departments of health are to be given enlarged powers over water supplies and sewage disposal, or to exercise any such powers, they should be composed of men competent as experts to deal with the engineering questions which govern the proper decision of water-supply and sewage-disposal questions. These questions should be decided by engineers, not by physicians. Massachusetts has done more than any other state in the Union to protect its public water supplies, and its work has been done under the direction and advice of engineers. This is largely the case in other states which have embarked on state control of water supplies and sewage disposal. Too often, however, the engineer does not have a direct voice in the final decision of these departments, but is merely a paid servant or adviser, even if, as is not always the case, his advice is held in high esteem and generally followed.

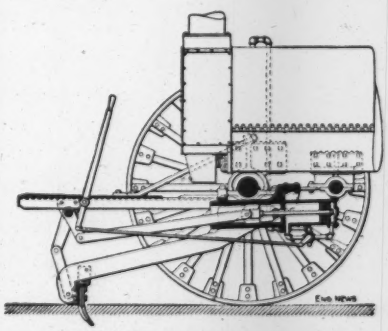
For the welfare of Pennsylvania and for the general advancement of water- and health-protection work everywhere, it is to be hoped that the Pennsylvania and other state health departments will take the Pittsburg experience as a lesson, and will base future orders for sewage-purification works or plans on a rational conception of the sewage-disposal and water-supply problems, and the relation of expenditures for either toward the other and toward other municipal needs; not forgetting that they exist to safeguard the rights of the city under orders, as well as those of the communities which they are primarily aiming to protect.

Finally, the Pittsburg reports, with the remarkable series of reports on sewage treatment at Rochester, N. Y. (see our issue of Aug. 11, 1910, for lengthy abstract and editorial comment), by Emil Kuichling, Allen Hazen, X. H. Goodnough, F. H. Snow and Theodore Horton, will long be landmarks in the history of sewage disposal. They show the sanitary engineer as a true and the greatest of conservationists, zealous to safeguard health and prolong life, but sparing no pains to see that each dollar is spent to the best advantage, in accordance with the fundamental principles of sanitary science.

A Scarifying Attachment for Steam Road Rollers

The scheme shown in the accompanying figure is intended to supplant the use of spikes on the rear wheels of a road roller in breaking up the surface for repair. With the use of spikes in the wheels two separate strips are scarified and it is necessary to run over the road several times. This device is as wide as the roller and opens up a single broad strip of pavement.

The attachment is built to, and made a part of, the roller. Nine heavy spikes are attached to the front of a heavy Z bar, which is connected by strong rods to the rear axle, on which all the pulling stress comes. The shape of the spikes is such that as the roller travels forward they are drawn into the ground, tearing and breaking it up to a sufficient depth to leave the whole mass loose and in condition to be easily shaped up by a grader. When not in use, the spikes are carried clear of the ground and high enough so that they do not interfere with any other use of the roller.



THE HUBER SCARIFIER FOR STEAM ROAD ROLLERS

The scarifier bar is raised and lowered by admitting steam to a double-acting cylinder, the piston of which moves a crosshead on the end of the long arm of a bell-crank lever. The control valve is operated from the engineman's platform.

The spikes are held in the ground by steam pressure; this gives a desirable cushioning. If rock should be encountered this cushion allows the spikes to lift enough to pass over without breaking the device or injuring the roller. The steam pressure causes the scarifier to follow an uneven road surface and it is claimed that a constant depth of penetration is secured.

Naturally, a roller with this scarifier must be built with greater tractive power than required for simple rolling; the engine used is rated at 16 hp. at low steam pressure, but its capacity can be raised greatly by bringing up the boiler pressure.

This scarifier is made by the Huber Manufacturing Co., of Marion, Ohio, from whom these details have been received.

Failure of A Log and Earth Fill Dam at Union Bay, B. C.

By A. K. Mitchell*

On Feb. 10, 1912, as a result of the failure of an earth and timber dam on a creek emptying into the Straits of Georgia, a considerable part of the settlement at Union Bay, B. C., was entirely washed out, one Japanese laborer was drowned and property estimated at $50,000 was destroyed. The flood occurred at 5 o'clock in the afternoon when many of the inhabitants were just returning from work, and it is due solely to this fact that the loss of life was so small. The government telegraph office and about fifty shacks belonging to Chinese and Japanese were swept out to sea, several other buildings were irreparably injured, and

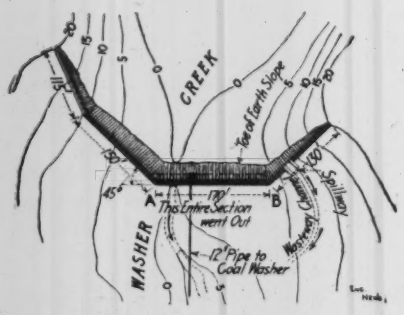


Fig. 1. Plan of Union Bay Dam of the Canadian Collieries, Ltd. Failed Feb. 10, 1912

part of the railroad track was undermined. Many houses caught fire as they were carried out into the bay, their occupants with them, and it was the light of these which guided the boats in the work of rescue until late into the night.

Union Bay is situated on the east coast of Vancouver Island some 60 miles north by automobile road from Nanaimo, and is the shipping point of the Cumberland and Union mines of the Canadian Collieries, Ltd., which were recently purchased from the Dunsmuir estate by Sir William MacKenzie. The large coal washing and screening plant and the wharves and bunkers at Union Bay are connected with the mines by a standard-gage railway owned and operated by the company. The product of the mines is the best steaming coal mined on the Coast, and a ready market is found for the 3000-ton daily output. Many ships, among them those of the Canadian Pacific Ry. Co.'s Australian line and the Blue Funnel line, put into Union Bay to coal, and the majority of others touching at Vancouver use coal which is shipped across by scows. Furthermore, there is always a large direct shipping to American and Mexican Pacific ports.

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Water for coal washing and power at the Union Bay plant is obtained from a lake 600 ft. above sea level and four miles up the stream flowing through the town, which is locally termed "Washer Creek." Some four or five years ago the company laid a steel pipe line to the lake and to conserve the winter run-off, built a dam (Fig. 1) raising the lake 18 ft. and giving a storage capacity of approximately 6000 acre ft. The down-stream face (Fig. 2) was composed of two walls of flattened 24-in. logs, spaced 5 ft. c. to c. by small cross pieces, and built up by laying one timber upon another and drifting them together by occasional 2-in. wooden pins. This structure was filled with earth. It extended up to elev. 17, above which rose a 1 to 1 earth slope to a 3-ft. crest at elev. 20. Along the crest was laid a longitudinal capping of small logs which had no apparent function. From the crest to the water toe the earth sloped on an average of 1¼ to 1. Buried within the earth fill of the central section which went out was a 10-ft. crib of 15-in. round logs in 10-ft. squares, just in front of the heavy timber backing, but having no connection with it.

The spillway (Fig. 3) located in one of the wings which remained intact, consisted of a plank structure 15 ft. in width and 3 ft. in depth, with a central portion half as wide and 2 ft. deeper. A middle post divided the whole section and permitted the use of shorter flashboards, which fitted into guides made of small rolled angles.

The main dam extended 170 ft. across the lowest part of the valley and was flanked by wing dams, each making an interior angle of 135° on the water side. These were of the same construction with the exception of the omission of the crib buried within the fill. The junctions of the timber back of the main dam and the wings was effected by simply resting the upstream side of each wall of the former behind the beveled ends of those of the latter, no bond of any kind being provided (Fig. 4).

The dam timbers rested directly on hardpan and conglomerate only a foot below the natural lake level, and there was no evidence, after the failure, of any attempt to bond them with the foundation.

At the head of the 12-in. pipe was a rectangular log well, built into the crib just in front of the timber backing. This was furnished with a gate and a sluice leading through the earth toe.

The writer reached Union Bay on the afternoon of Feb. 12, 48 hours after the failure. Everything in the V-shaped mouth of the creek between the bench slopes and the beach was swept clean by the flood, and practically nothing remained but the railroad trestle to the wharf bunkers, which was of very heavy construction, and the coal washer itself, which was too high to be damaged. The residents reported the advent of the flood as a 10-ft. wall of water 500 ft. wide at the upper end of the town, which gave a minute's warning by its roar farther up the stream. It is said that the flood continued at its maximum intensity for half an hour after 5 p.m., and that after two hours it was mostly over, although at 10 o'clock the creek was still swollen. Assuming the total reservoir capacity at 6000 acre ft. and that 5000 acre ft. reached the town in the first two hours, the average flow during that time must have been 30,000 cu.ft. per sec., and the peak of the wave perhaps 50,000. The maximum normal winter flow of the creek at the town is probably never more than 75 sec.ft.

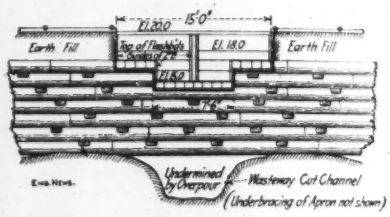

Fig. 3. Rear View of Spillway, Showing Flashboards in Position at Time of Failure

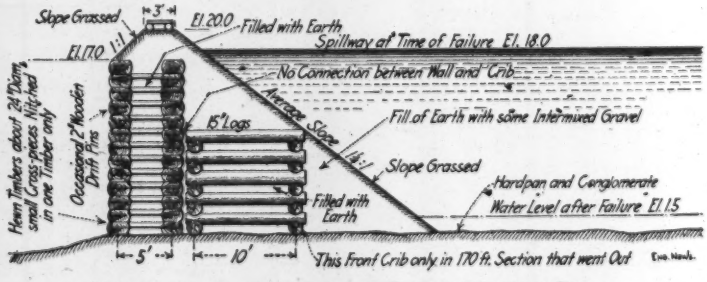
Slope Grassed
3'
El. 20.0
Filled with Earth
Spillway at Time of Failure El. 18.0
El. 17.0
No Connection between Wall and Crib
Average Slope
15" Logs
Fill of Earth with some Intermixed Gravel
Slope Grassed
Hardpan and Conglomerate
Water Level after Failure El. 15
Filled with Earth
Hewn Timbers about 24" Diam., small Cross-pieces Notched in one Timber only
Occasional 2" Wooden Drift Pins
5'
10'
This Front Crib only in 170 ft. Section that went Out

Fig. 2. Maximum Section of Dam at Stream Bed

Above the town along the cañon the evidence of the size and force of the wave was most striking. Great Douglas firs had been uprooted and piled into enormous jams extending from side to side of the gulch. The substructure of a high timber trestle carrying a logging railroad across the valley had gone out, leaving only the track suspended by the

rails. Where the creek bed was in earth and gravel it had been scoured many feet deeper. A quarter of a mile below the lake appeared the first pieces of the débris of the dam; a whole section of the timber backing which had been left by the flood 25 ft. above the stream bed. Just above this point the pipe line joins the course of the creek and sections of it were entirely gone.

Most of the dam timbers lay scattered irregularly within 100 ft. of the site. The whole central section, 170 ft. in length, had gone out, leaving only the gate well and the lower courses of part of the buried front crib. At the end opposite the spillway wing, a section of the timber backing had been turned through an angle of 90° and lay longitudinally just below the end of the wing dam, apparently having turned upon that as a pivot. In few cases did one timber remain on top of another, as most of the wooden drift pins were snapped or sheared. Furthermore, examination of the timbers showed that only about half of the holes bored to receive these pins had ever had the pins driven into them.

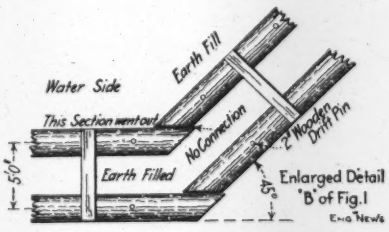

FIG. 4. ENLARGED PLAN OF CORNER DETAIL OF DAM

Lying on the earth slope on the lake side of the spillway was a mass of logs and brush, which had evidently subsided there after the lowering of the lake due to the dam's rupture. The top of the rigid flashboards being but 2 ft. below the top and the spillway being obstructed by the middle post and top cross-bar, it could have taken but little stoppage from floating débris to have raised the water level to a point dangerously near the crest, if, indeed, overtopping of the earth crown at some point slightly lower than the wings did not actually occur. On the day of the writer's visit the discharge from the lake through the break was approximately 12 sec.ft., but during the day preceding the failure it is reported to have rained heavily, and the influx to the reservoir must therefore have been considerably greater than this. The draft through the 12-in. pipe must have been so small as to be nearly negligible.

It is the writer's opinion that overtopping of the central portion of the dam was the cause of incipient failure, and that the semiporous, narrow-crested, and steep-sloped earth fill sloughed off at once to the level of the top of the timber backing. This latter was then subjected to practically full hydrostatic pressure, and being in itself unstable and poorly joined and anchored, immediately went out by a combination of overturning as a whole and by the sliding of its courses one upon another and upon the bottom. If this opinion be correct, the presence of an attendant to remove the flashboards would have prevented the failure.

The wonder is not so much how the dam failed as rather how it ever before could have remained intact with the reservoir full. The vertical timber back was a great point of weakness, and probably only the leaking through it of the water which filtered through the earth prevented its being subjected to enough pressure to overturn it or push it out. The buried crib was absolutely useless. The earth fill was of wretched surface scrapings and apparently no attempt had been made to deposit it properly or to thoroughly compact it. Aside from the danger of overtopping due to the inadequate and obstructed spillway, the structure as a whole presented a ludicrous example of a dam which would have been more stable if the front and rear faces had been reversed.

This failure may not be as instructive from an engineering point of view as one of a large masonry dam, yet the volume of water released was not inconsiderable, and had it occurred at night at least a hundred lives might have been sacrificed to inexcusable ignorance and carelessness in the design and construction of a general class of structure, which, for many reasons, will long continue to be common in new and timbered districts.

The Failure of the Spang-Chalfant Reinforced-Concrete Building, Pittsburg, Penn.

On Feb. 19, 1912, about 10 a.m., a portion of a three-story reinforced-concrete building under construction as a part of the plant of the Spang Chalfant Co., Inc., at Etna, a suburb of Pittsburg, Penn., collapsed after some warning noises that caused most of the workmen to seek a place of safety. Four men were caught in the fall and were seriously injured, but fortunately, contrary to early reports, no one was killed outright.

At our request, Messrs. Irvin & Witherow, of Pittsburg, the designing engineers of the building, have forwarded us a brief statement of the design of the building and the conditions precedent to its collapse. We print this below, together with another account of the collapse, prepared for us by Edward Godfrey, a structural engineer of Pittsburg. The halftones which are reproduced herewith are from photographs furnished us by Mr. Godfrey.

IRVIN & WITHEROW'S STATEMENT

The building under construction for the Spang Chalfant Co., Inc., in the Borough of Etna, Penn., near Pittsburg, fronts on Bridge St., and is approximately 467 ft. long and 100 ft. wide, with an ell 142 ft. long and 100 ft. wide at one corner. The main portion of the building fronting on Bridge St. is principally of reinforced concrete two stories high. Beginning at the northwest corner the first 80 ft. has a full second floor. That portion in immediate connection with this and extending southeast for approxi-

FIG. 1. VIEW SHOWING WEST SIDE OF COLLAPSED REINFORCED-CONCRETE BUILDING, ETNA, PENN.

(Note thickness of cinder fill on the collapsed roof.)

mately 300 ft. has a two-story balcony, 25 ft. wide, extending entirely around, while the interior portion, 50 ft. in width, is spanned by steel trusses on top of which there is a concrete roof slab. The final 80 ft. is directly connected to the preceding section, but is entirely of reinforced concrete, three stories in height, and is to be used as an office building. This entire building rests on concrete piles varying in length from 23 to 42 ft. The piles are of the molded-in-place variety.

Plans and specifications for the entire work, as well as all details for structural steel and reinforced concrete, were prepared by Irvin & Witherow, engineers, Keystone Building, Pittsburg, Penn.

On Feb. 19, 1912, at about 9:30 o'clock in the morning, the southeastern portion of the building, known as the office building, collapsed. This section fronts on Bridge St. 80 ft. and is 100 ft. deep. It is entirely of concrete construction, three stories high. That is, the first floor is directly on the ground except in the rear, where there is a 50x60-ft. basement. The column spacing is 20x25 ft. The basement has a depth of 8 ft. 10 in.; first to second floor, 20 ft. 6 in.; second to third floor, 13 ft. 6 in., and third floor to roof, 13 ft. 6 in. The roof is flat or level and the drainage obtained by a cinder fill sloped from front to rear. The maximum cinder fill is 26 in.

An examination of the premises about two hours after the failure showed that the cinder fill was frozen solid. Cakes which had fallen approximately 50 ft. were found from 12 to 20 in. in thickness, and containing from 80 to 100 sq.ft.

Portions of the roof slab, beams and columns were found which could be broken with the hand and kicked apart with the foot. Fractures of these parts showed no broken pebbles. The concrete in small sections was mushy, wet and soft. New fractures of heavy sections showed small crystals of ice on the interior. Samples taken at this time and kept in the office until Feb. 26, 1912, containing about 100 cu.in., could be broken with the hands.

The roof concrete was poured from two to four days before Christmas, and the cinder fill was deposited about Jan. 10, 1912. The centering had all been practically removed, but a few props remained in the second and third floors. The weather had been continually very cold from the time of pouring until Feb. 16, when a heavy thaw set in.

The majority of the material fell inward and the columns still standing all point approximately to a common center. The columns still standing show the conical fracture. The reinforcing steel was of the medium open-hearth variety, and shows some remarkable twists and bends. In no case yet discovered has the steel been stretched beyond the elastic limit.

Every indication so far shows that the second and third floors were satisfactory and substantial and that the collapse was due to the failure of the roof, the falling of which carried with it the third and second floors. From indications and reports from men on the work, it is probable that the roof columns failed first.

The design was in accordance with the usual and standard practice, principally of mechanical bond bars. Columns all contained from four to eight bars laced every 12 in. with No. 3 wire. Roof columns were 12x14 in. Girders were 14x26 in., spanning 25 ft. The slab was an arch spanning from girder to girder 4 in. at the crown, and 12 in. at the haunch and amply reinforced. The design of the office portion was similar to the balance of the work. The balance of the work, 380x100 ft., is partially occupied, and is proving satisfactory. Since the failure the design has been carefully checked by the engineers, Irvin & Witherow, as well as by independent outside engineers of wide experience, and all have agreed that the design is absolutely satisfactory and stable.

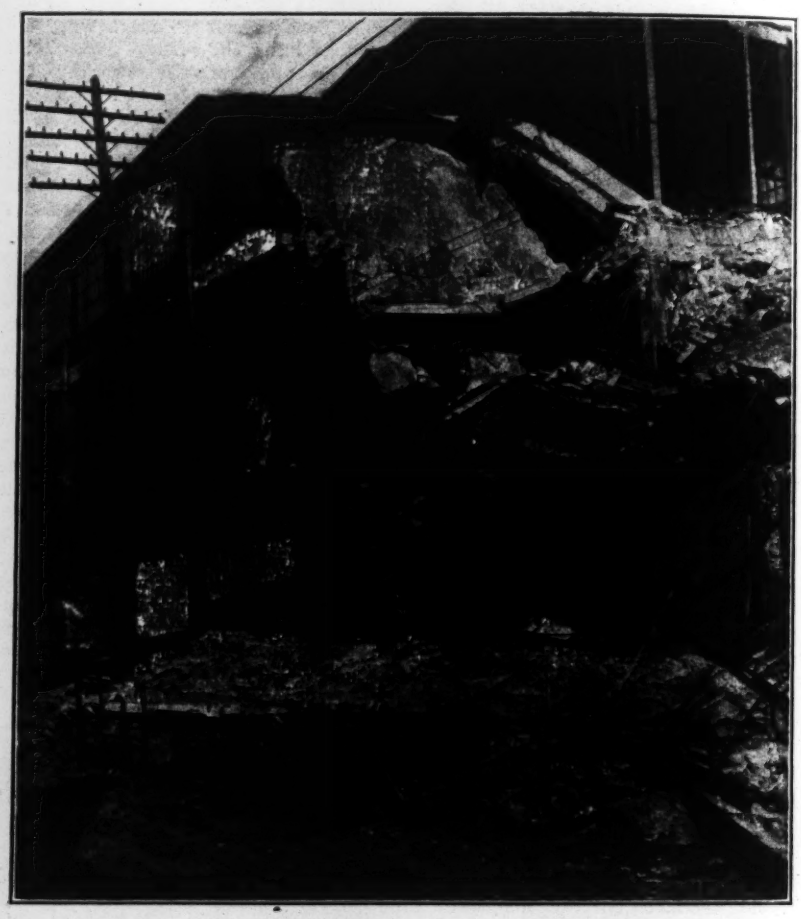

FIG. 2. VIEW OF JUNCTURE OF SHOP AND COLLAPSED OFFICE BUILDING
(Column inclosed in circle broken.)

MR. GODFREY'S REPORT

The failure was in the three-story portion of a nearly completed structure being erected for the Spang Chalfant Co., Inc., in Etna, a suburb of Pittsburg. This portion of the building was to be used as an office building by the owners, one of whose shops adjoins and forms part of the same structure. The contractors are B. A. Groah & Co., of Pittsburg, and the architects Irvin & Witherow, also of Pittsburg. C. R. Irvin, of this firm, designed the reinforced-concrete work.

The portion of the building which collapsed was about 100 ft. square. Fig. 1, herewith, shows the west side of the building. The collapse occurred on Feb. 19, at about 10 a.m. Some warning noises were heard very shortly before the collapse, so that some of the workmen had time to escape. Four men were severely injured. Others had narrow escapes. The wreck is complete as regards the office portion of the building.

The slabs and girders were of reinforced concrete. The reinforcement consisted of Kahn trussed bars and Kahn deformed rods. The columns were con-

crete shafts with slender rods near the corners. Kahn deformed rods were used here also.

Parts of the forms were still in place under the roof slab. Lagging can be seen in many places still in contact with the roof slab; also parts of the beam boxes still surround the beams in some cases. The writer was informed, however, that most of the forms had been removed.

The floors and roof consisted of wide-span slabs on girders. These slabs were thin at the middle of span and thick at the girders, doubtless so designed for cantilever or arch action.

There was a large amount of weight at the roof level. Cinder fill was used to give the roof a slope. This fill reached a depth of about 2 ft. in parts of the roof. The cornice was quite massive. The roof covering was not placed and the cinder fill was water soaked and partially frozen. There was no snow or ice over the cinders, but there was some ice overlying the slab that had evidently been there when the cinders were put down.

The collapse occurred soon after the beginning of comparatively mild weather which followed a long period of low temperature.

The last of the concrete was poured a day or two before Christmas. The weather since that date has been almost continuously below freezing; on several occasions it has been below zero. Little is said to have been done in the way of heating the building. While in some parts the concrete is hard and strong, in others it is weak.

The failure must have been at or above the second floor, for most of the columns remain upright, though not vertical, to this height. Nothing remains above this level except the parts still attached to the portion of the building which did not collapse.

There are three phases of weakness that are strongly in evidence. These are weak concrete, weak attachment of girders to columns, and weak columns.

The part played in the wreck by weak concrete would depend upon the number of props that were still in place. The roof concrete is far from being hard enough to be self supporting.

The weak attachment of girders to columns shows up in the apparent ease with which girders and columns parted company. The interior columns which are standing are stripped bare of any sign of girder attachment. The girders which framed into wall columns are sheared off and show a few short ends of rods projecting.

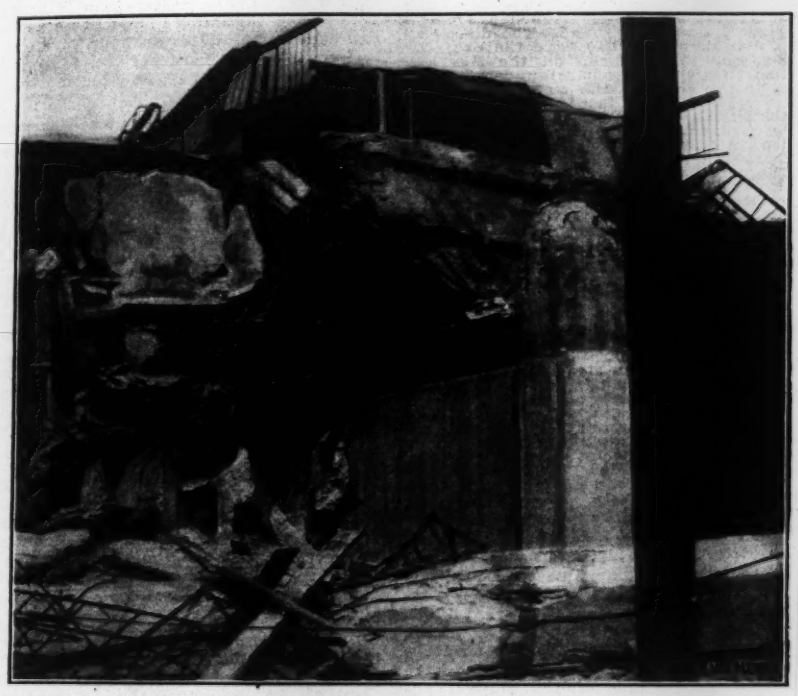

FIG. 3. VIEW OF CORNER OF COLLAPSED BUILDING, SHOWING TYPICAL COLUMN FRACTURE

The columns of this building were shafts of concrete with slender rods in them. It is easy to imagine that the noises heard before the failure were produced by chunks of concrete breaking off the corners of the columns, where there was nothing to hold them on but tension in concrete and where there was a slender rod in compression to shove them off. The hardened "skin" of the concrete would be the first to receive the compression. A typical rounded end of a fractured column can be seen in Fig. 3. Some of the slender rods are curled up in fantastic shapes, illustrating what a straight line will do when it is called upon to act as a column.

One of the most significant features of the wreck is located some 60 or 80 ft. away from the wreck itself. As stated, the wrecked portion adjoins a shop building (Fig. 2). This building has outer columns supporting a gallery or second floor and the roof. There is large window space in the sides. The column at the corner of the wrecked portion, acting to support both office building and shop, was, of course, badly damaged, though it is in place for its full height. (In Fig. 2, taken four days after the wreck occurred, this column has been torn down.) The next two columns, away from the wreck, are apparently perfectly sound. The next column failed at about the middle of its height by bulging, at the location marked by a circle on Fig. 2. It did not let down its load nor break the windows, but it is evidently broken in two, showing the fracture on both inside and outside of the building. This column was put in last summer and is thoroughly seasoned. It must have failed from the quaking of the earth, for it has no connection with the wreck except through the medium of apparently sound structure and earth.

The side girders of a stairway also located some distance from the wrecked portion cracked near the supports.

A Tornado in Arkansas, Feb. 25, devastated portions of Lincoln, Jefferson and Arkansas Counties. Reports state that ten persons were killed and 25 others severely hurt.

A Boiler Explosion at Bond, Miss., Feb. 19, wrecked the plant of the Bond Lumber Co. Four men were killed and two others injured.

A Mine Fire at Lehigh, Okla., started, Feb. 22, in mine No. 5 of the Western Coal & Mining Co. All but nine of the 170 men in the mine were gotten out alive, and eight dead bodies were brought out by rescue parties.

A Rear Collision in the Hoosac Tunnel, Feb. 20, on the Fitchburg division of the Boston & Maine R.R., caused the death of four trainmen and put a stop to all traffic through the tunnel for a number of days. The accident occurred about 2500 ft. from the east portal. A freight train of 32 cars was stopped at this point for some reason and a flagman was sent back to warn a passenger train following. The passenger train stopped, took on the flagman and proceeded at reduced speed. For some cause not yet ascertained, the passenger train, instead of stopping collided with the caboose of the freight.

The electric locomotive of the passenger train and the freight caboose were wrecked. Fire started in the wreckage and spread to other cars of the freight train. The passenger train was saved by backing it out of the tunnel, which was done by the steam locomotive behind the electric. It is the practice to haul passenger trains through the tunnel with the steam locomotive attached. The fire continued for two or three days. Attempts to extinguish it with apparatus taken into

the tunnel from North Adams, Mass., were unsuccessful on account of the intense heat and dense smoke in the tunnel. It is reported that the tunnel roof was heavily damaged by falls of rock occasioned by the heat. The origin of the fire, according to one report, was not from an electrical short-circuit, but from a coal stove in the freight caboose.

An Unprecedentedly High Wind was recorded in New York City on Feb. 22, 1912. Starting about 12:30 a.m., with sudden gusts from the northwest, it reached it maximum about 1:08 a.m., when for five minutes the anemometers of the U. S. Weather Bureau on the Whitehall Building at the southern end of Manhattan Island reached an average velocity of 96 miles per hour, during one minute of which time the record was 120 miles per hour. Thereafter, the records are as follows:

1:30 a.m.	46 mi. per hr.	W.
2:30 a.m.	61 mi. per hr.	S.W.
3:30 a.m.	40 mi. per hr.	N.W.
5:00 a.m.	58 mi. per hr.	W.
6:00 a.m.	60 mi. per hr.	W.
7:00 a.m.	65 mi. per hr.	N.W.
9:30 a.m.	71 mi. per hr.	N.W.
11:00 a.m.	71 mi. per hr.	N.W.
12:00	70 mi. per hr.	

All of the afternoon the velocity was between 50 and 65 miles per hour, and did not lower to normal until late at night. The wind was preceded by a heavy rain storm, which stopped about midnight of Feb. 21-22.

Comment on the above record of wind velocity is made on our editorial pages.

The storm felt in New York, Feb. 22, had crossed the country from the southwest. Heavy damage to property was done in northern Louisiana and Mississippi, Feb. 20. Reports state that eight persons were killed and 50 injured in the outskirts of Shreveport, La., on that date. Severe blizzards in some of the Middle Western States, Feb. 21, seriously interfered with steam and electric railway traffic. A number of trains were stalled by snow drifts and several minor accidents due to the storm were reported. In western Pennsylvania, hundreds of oil derricks were blown down, Feb. 21 and 22, and at Washington, Penn., the main building of the Washington and Jefferson College was unroofed. In New York City the chief damage was to signs and windows.

A Postal Rate of 2c. per lb. on second-class mail matter is recommended by the Commission appointed by President Taft a year ago and made up of Justice Hughes, of the U. S. Supreme Court, President Lowell, of Harvard University, and Harry A. Wheeler, President of the Chicago Association of Commerce.

The Commission finds as a result of its investigations that the present cost to the Post Office Department for carrying second-class mail matter is about 6c. per lb., which will be reduced to about 5c. per lb. when further economies are introduced in the transportation of bulky periodicals by fast freight. The Commission holds, however, that a postal rate on publications high enough to cover the entire cost of their handling would be for many reasons undesirable, and advises that the increase in rates be only to 2c. per lb.

A $50,000,000 Bond Issue for Good roads in Ohio is favored by the Constitutional Convention in Ohio, the final vote on the proposition being 72 to 40. The present Ohio Constitution limits the state debt to $750,000. The proposed amendment permits the issue of state bonds to an aggregate amount not to exceed $50,000,000 of which not more than $10,000,000 shall be issued in any one year, to be expended in maintaining, constructing, improving, repairing and rebuilding a system of intercounty wagon roads throughout the state.

The Cause of the Warrior Ridge wreck on the Pennsylvania R.R., Feb. 15, was investigated, Feb. 16, by Marshal John P. Dohoney for the Pennsylvania State Railroad Commission. The following extracts from Mr. Dohoney's report give the chief results of the investigation:

A consideration of all the information obtained leads to the conclusion that the breaking of an arch bar on the first truck of the tender of the second engine, No. 3350—there being two engines attached to the train—was the primary cause of the derailment; and this is the generally accepted theory of others who were assigned to the investigation.

An inspection made after the accident showed that beginning approximately a mile west of Warrior Ridge station the roadbed showed evidence of a defect in some of the mechanical parts of the train. The ties were scored as if from the impact of an iron slab and bolts and nuts that had been wrenched from a truck frame were found. The discovery of a broken arch bar gave the explanation for these marks on the ties and also furnished a general understanding as to the cause of the wreck.

The belief is that this bar pounded along the track until a switch was reached, that the point of the latter was broken and that in consequence thereof the south rail was shoved out of place. The derailment followed. The foregoing theory is strengthened by the fact that nothing was disclosed to indicate other contributory defects in the train equipment.

An examination of the break in the arch bar showed what appeared to be a flaw in the wrought iron about 2½ in. in length, but whether this occasioned the fracture and brought about the disaster is a matter that only a scientific analysis can determine.

The train, all steel, was made up in the following order: One mail car, one combination, three sleepers, two diners, three sleepers and one observation. An inexplicable feature of the accident is that the mail car, which was attached to the rear tender and coupled with the combination car, was not derailed. It separated from the latter and, drawn by the engines, traveled about half a mile beyond the wreck before coming to a stop.

A Bill to License Civil Engineers was introduced in the New York Senate, on Feb. 15, by Mr. Harte and was referred to the Senate Committee on Education. The Chairman of this committee is Senator Robert H. Gittins, of Niagara Falls. The bill is similar to the McGrath bill, introduced in the New York legislature a year ago, but never reported by the committee because of the general opposition of engineers throughout the state. The present bill establishes a State Board of Engineering Examiners, which is to examine and issue licenses to successful applicants for a fee of $25. The State Board of Regents is to appoint the engineering examiners, and is in general given broad powers over persons seeking to enter the engineering profession. The arguments against such legislation were fully set forth a year ago in various numbers of Engineering News, from Jan. 26 to May.

Responsibility for the Bridgeport wreck of the Federal Express on the New York, New Haven & Hartford R.R., on July 11, 1911, it has been decided, does not rest with the management of the railway company. The finding of the coroner was that the company was criminally negligent (Eng. News, July 27, p. 127); but an investigation has been conducted by F. P. Patenall, Signal Engineer of the Baltimore & Ohio R.R., at Baltimore, Md., and A. H. Mitchell, a civil engineer, of New York City, for the State's Attorney of Connecticut; they have reported that no blame should be laid to the railway management.

Demands for Increased Wages by the locomotive engineers of the railways east of Chicago and north of Virginia are to be considered by a committee of 12 vice-presidents and general managers. The schedule of pay demanded by the engine runners is as follows: In passenger service, for engines with cylinders of 20 in. or less diameter, $4.20 per hundred miles or less; engines with larger diameter cylinders, $4.60 per hundred miles; over-time to be paid for at 70c. an hour on the basis of 20 miles run per hour; electric locomotives to be run at the same rate as steam locomotives; freight service, minimum rate, $5.25 per hundred miles for engines with 20-in. cylinders or less; $5.50 for engines with cylinders of 20 to 24 in., $5.55 for larger cylinders; Mallet locomotives, $7. One hundred miles or less, or 10 hours or less, is to constitute a day's work. Over-time is to be paid for on the minute basis at an average speed of 10 miles an hour. Switching engines and yard service, $4.50 per day of 10 hours; belt-line locomotives, $5 per day of 10 hours.

A Proposed Tunnel under The Narrows from Brooklyn to Staten Island is contemplated by the Public Service Commission. It is recommended by a committee of the commission that the 4th Ave. subway now about 80% completed be extended in South Brooklyn toward Fort Hamilton, with the idea of eventually continuing it as a tunnel under the Narrows, by which name the main ship channel entering New York harbor is commonly known, to a terminus on Staten Island.

A Railroad Educational Bureau will be established by the Central of Georgia Ry., on Mar. 1, the plan of the Union Pacific R.R., as outlined in Engineering News, Oct. 7, 1909, p. 376, being followed.

The bureau aims to prepare the railroad's employees for promotion along lines which they select and for furnishing information to them of use in their regular work; correspondence courses are largely used. This bureau will be located at Savannah and under the direction of Mr. D. C. Boy, formerly of the Union Pacific R.R.

A Blended Sand and Cement is to be manufactured by the U. S. Reclamation Service for use in the new Arrowrock Dam at Arrowrock, Idaho. According to a bulletin of the Reclamation Service, this plant will have a daily output of 1000 bbl. of 40% blend sand-cement and will cost approximately $40,000. The product will be utilized in the construction of the Arrowrock Dam, which is to be the highest masonry dam in the world. This large structure will be 351 ft. in height and will require 500,000 bbl. of cement. The engineers estimate that the use of the blended sand and cement will effect a saving of more than $250,000 in the cost of the dam. Experiments in the dilution of cement with extremely fine ground silica, notably on the Los Angeles aqueduct, have shown that great economy can be effected in concrete construction. On the aqueduct work the cement is being reground with volcanic rock, the latter comprising from 60 to 70% of the whole. This mixture is being used in the usual way in making concrete and is standing all the tests as to strength and other qualities. At the Arrowrock site there is an abundance of granite which will

make a first-class blending material, the use of which it is believed will result in great saving in the cost of cement.

Three **Administrative Commissioners** of city affairs in the cities of Saskatchewan, Can., are provided for by the statutes of that province. It appears that one of the three commissioners must be an engineer. L. W. Rundlett, formerly City Engineer of St. Paul, Minn., has been appointed as engineer commissioner of Moose Jaw at a salary of $6000 per year. The city clerk at Moose Jaw, W. F. Heal, has resigned his position to become a second commissioner, at a salary of $3000 a year. The third commissioner is the mayor, who holds his office ex-officio. There will also be a city engineer selected as the result of advertising for applicants for the position, in accordance with the very common practice in British cities. It appears that the legislative functions of Moose Jaw are exercised by a council and that this body fixes the powers and duties of the two members of the commission other than the mayor, selects the commissioners and fixes their salaries. The office of engineer commissioner, however, was not filled until applications for the position had been received as the result of advertising.

Personals

Mr. John H. Marble, a lawyer, of California, has been appointed Secretary of the Interstate Commerce Commission.

Mr. E. F. McCrea has been appointed Division Engineer of the Pennsylvania R.R., at Toledo, Ohio, succeeding Mr. Guy Scott, transferred.

Mr. W. H. Dittoe, Jun. Am. Soc. C. E., who has been Acting Chief Engineer of the Ohio State Board of Health since Dec. 1, 1911, has been appointed Chief Engineer.

Mr. W. W. Chaffin has resigned his position as Engineer in Charge of Track Elevation, at Fort Wayne, Ind., of the Pennsylvania R.R., to become Assistant City Engineer of Fort Wayne.

Mr. Ernest A. Sterling has resigned his position as Forester of the Pennsylvania R.R. to open an office at 1331 Real Estate Trust Bldg., Philadelphia, Penn., as a consulting forest and timber engineer.

Mr. Richard L. Saunders, formerly employed on the engineering staff of the Board of Water Supply of the City of New York, has resigned to become Assistant City Engineer of Bridgeport, Conn.

Mr. W. S. Tinsman, General Manager of the first district of the Chicago, Rock Island & Pacific Ry., of Chicago, Ill., has been elected President of the Memphis & Arkansas R.R. Bridge & Terminal Co., succeeding the late J. T. Harahan.

Mr. William H. Connell, Assistant Commissioner of Public Works of the Borough of The Bronx, New York City, has been appointed Chief of the Bureau of Highways of Philadelphia, Penn., succeeding Mr. W. R. Benson, resigned.

Mr. George Hodge, formerly Division Superintendent of the Canadian Pacific Ry., at London, Ont., has been promoted to be General Superintendent of the Eastern Division at Montreal, Que., succeeding Mr. E. P. Gutelius, resigned.

Mr. P. H. McFadden has been promoted from the position of Division Roadmaster, at Everett, Wash., to that of Assistant Engineer of Maintenance-of-Way of the Western district of the Great Northern Ry. His headquarters will be at Seattle, Wash.

Mr. George H. Herrold has been appointed Office Engineer for the Commission of Public Works of St. Paul, Minn. Mr. Herrold has been in private practice in St. Paul for a number of years, and was formerly Engineer of Maintenance-of-Way of the Chicago Great Western Ry.

Messrs. Thomas L. Way and Joseph Maitland have formed a partnership, with offices in Johnstown, N. Y., for the general practice of engineering. Mr. Way has been employed in the New York State engineering department since 1909, and Mr. Maitland was formerly of Pittsfield, Mass.

Mr. H. H. Quimby, M. Am. Soc. C. E., Assistant Engineer of the bridge division of the Bureau of Surveys of Philadelphia, Penn., has resigned to enter private practice with Mr. John G. Brown, Assoc. Am. Soc. C. E., as consulting engineer. Previous to his work with the city of Philadelphia, Mr. Quimby was for many years with the engineering staff of the Phoenix Bridge Co. He is the designer of the Walnut Lane reinforced-concrete arch bridge, the Passyunk Ave. bridge and many other bridges of steel and concrete in Philadelphia.

Mr. Matthew C. Brush, formerly Assistant to the President of the Boston Elevated R.R., has been elected Second Vice-President, a newly created office. Previous to joining the staff of the Boston Elevated R.R. in 1909, Mr. Brush was General Manager of the Buffalo & Lake Erie Traction Co., the Jamestown, Chautauqua & Lake Erie R.R. and the Jamestown & Chautauqua Steamship Co. Mr. Brush is a graduate in mechanical engineering of the Massachusetts Institute of Technology, class of 1901, and received his first engineering experience as an apprentice in the shops of the Union Pacific Ry.

Obituary

Henry Richmond, formerly City Engineer, of Nashua, N. H., died, on Feb. 21, at the age of 88 years.

Frederick Adee Smith, General Eastern Manager of the Neptune Meter Co., of New York City, died, on Jan. 30.

Leander N. Lovell, Chairman of the Bituminous Coal Trade Association, died, on Feb. 19, in New York City.

Capt. Philip R. Alger, Professor of Mathematics at the United States Naval Academy at Annapolis, Md., died in the Naval Hospital at Washington, D. C., on Feb. 23. He was born in Boston, Mass., Sept. 29, 1859, and graduated from the Naval Academy in 1876. During the Spanish-American War he served in the Bureau of Ordnance.

Theodore F. Townsend, official forecaster at the Philadelphia, Penn., office of the United States Weather Bureau, for 25 years, died at his home in Cape May, N. J., on Feb. 22. He was 74 years old. Capt. Townsend entered the Government service in 1871. He resigned four years ago because of ill health, and retired to his old home at Cape May.

Dr. Charles R. Sanger, Professor of Chemistry and Director of the Chemical Laboratory at Harvard University, died on Feb. 25, at his home in Cambridge, Mass. He was born in Boston, Mass., Aug. 31, 1860, and graduated from Harvard University in 1881, receiving a Ph. D. degree in 1884. From 1881 to 1886 he was an assistant in chemistry at Harvard, and for the six years following was Professor of Chemistry at the United States Naval Academy at Annapolis, Md. Since then he had been at Harvard.

Joshua R. Barnes, formerly Superintendent of Motive Power of the Wabash R.R., at Springfield, Ill., died in that city, on Feb. 21. He was born in England in 1840, and came to this country in 1856, soon afterward becoming Master Mechanic of the Dubuque, Marion & Western R.R. From 1862 to 1882 he was General Foreman of the machinery department of the Wabash, St. Louis & Pacific Ry., later becoming Master Mechanic and Superintendent of Motive Power of the same railway, and of its successor, the Wabash R.R. He retired from active work about six years ago.

John Herron, M. Am. Soc. C. E., was killed, on Feb. 2, while on a visit of inspection to the Tom Boy Mine, at Telluride, Colo., of which he was Consulting Engineer. Some timbers fell on him as he was coming up the shaft. In 1885 Mr. Herron was engaged in railway work in Illinois under Mr. John F. Wallace, Past President, Am. Soc. C. E. Later he was employed on the engineering staff of the Montana Central R.R., under the late E. H. Beckler, M. Am. Soc. C. E., then Assistant Chief Engineer. About 1888 he went to Colorado and took up mining work, becoming Manager of the Tom Boy Mine, at Telluride. During the last eight years he had ceased active management of the mine but retained his connection with the properties in a more general and advisory capacity. He had also made several investigations of mining property in Mexico and elsewhere for the same English interests who own the Tom Boy Mine. He is survived by a widow, two daughters and a son.

Octavous Jones, Western representative of the Rensselaer Valve Co., died in Chicago, Ill., on Feb. 10, at the age of 66 years. The following is taken from a statement prepared by him a few days before his death: Octavous Jones was born at West Troy, now Watervliet, N. Y., on Apr. 8, 1845. From Apr. 1, 1860, he was for 28 years with the old Jones Troy Bell Foundry, of Troy, N. Y., and was for several years the head of the concern. During this period his company built some of the largest church and fire-alarm bells in Chicago, among them the old court house bell, which weighed 10,849 lb., and was destroyed in the great fire of 1871. His company also built in 1870 for the Michigan Ave. Baptist Church, of Chicago, the largest chime of bells ever cast in this country. The following year the chimes for the Metropolitan Memorial Church, of Washington, D. C., were built.

Mr. Jones became connected with the Rensselaer Valve Co., of Troy, N. Y., on Jan. 1, 1889. He came to Chicago as its Western representative in 1892, and had offices in the Monadnock block. He was a member of Masonic orders and a steward and trustee of the State Street Methodist Episcopal Church, of Troy, N. Y., for several years. He was an associate member of the American Water Works Association. Mr. Jones leaves a widow, daughter and two sons.

T. Guildford Smith, M. Am. Soc. C. E., Manager of Sales for various subsidiary companies of the United States Steel Corporation, at Buffalo, N. Y., died at his home in that city, from apoplexy, on Feb.

21. Mr. Smith was born in Philadelphia, Penn., Aug. 27, 1839. His early education was obtained in private and public schools of that city and at the Central High School, from which he graduated in 1858. Thereafter he went to Rensselaer Polytechnic Institute, graduating with the class of 1861, the class in which A. P. Boller, M. Am. Soc. C. E., of New York City, and the late E. A. Fuertes, M. Am. Soc. C. E., Director of the College of Civil Engineering of Cornell University, were also graduated.

Mr. Smith began engineering work with the Philadelphia & Reading R.R., and became Resident Engineer for this railway in the Mahanoy district of the anthracite coal fields. He resigned from the engineering staff of this railway in 1865, and for four years was Manager of the Philadelphia Sugar Refinery. After a visit to Europe in 1872 Mr. Smith became Secretary of the Union Iron Co., of Buffalo, N. Y., retaining this position for five years, when he was appointed Western Sales Agent of the Philadelphia & Reading Coal & Iron Co. In 1883 the firm of Albright & Smith was formed, as sales agents of the Reading Co. in New York State and Canada, and in 1889 Mr. Smith became Sales Agent for Carnegie, Phipps & Co., Ltd., of Pittsburg, Penn., which later became the Carnegie Steel Co., and still later a part of the United States Steel Corporation, of which Mr. Smith was the Buffalo representative.

Mr. Smith always took an active interest in educational matters. In 1890 he was elected by the state legislature a regent of the University of the State of New York, a position which he filled until recently. He also served as the chairman of the museum committee, which had charge of geological and other scientific surveys of the state. He was a member of many scientific, literary and philanthropic societies and associations. He had been a member of the American Institute of Mining Engineers since 1871, the year of its foundation, and of the American Society of Civil Engineers since 1871, which made him among the oldest members of this society. In 1894 he was the delegate of both these societies to the International Congress of Medicine and Surgery at Rome. At the time of his death he was President of the Committee of One Hundred which is arranging for the International Hygiene Congress, to be held in Buffalo in 1913.

Engineering Societies

COMING MEETINGS

NATIONAL PAVING BRICK MANUFACTURERS ASSOCIATION.
Mar. 4-6. Annual meeting at Chicago, Ill. Secy., Will P. Blair, 824 Engineer's Bldg., Cleveland, Ohio.

ILLINOIS WATER SUPPLY ASSOCIATION.
Mar. 5-6. Annual meeting at Urbana, Ill. Secy., E. Bartow, Urbana, Ill.

NATIONAL BRICK MANUFACTURERS ASSOCIATION.
Mar. 6-9. Annual convention at Chicago, Ill. Secy., T. A. Randall, Indianapolis, Ind.

CANADIAN MINING INSTITUTE.
Mar. 6-8. Annual meeting at Ottawa, Can. Secy., H. Mortimer Lamb, Room 3, Windsor Hotel, Montreal, Can.

NATIONAL ASSOCIATION OF CEMENT USERS.
Mar. 11-16. Annual convention at Kansas City, Mo. Secy., Edward E. Krauss, Harrison Bldg., Philadelphia, Penn.

AMERICAN BOILER MANUFACTURERS ASSOCIATION.
Mar. 12-15. Annual convention at New Orleans, La. Secy., J. D. Farasey, East 37th St. and Erie R.R., Cleveland, Ohio.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.
Mar. 19-21. Annual meeting at Chicago, Ill. Secy., E. H. Fritch, 962 Monadnock Block, Chicago.

AMERICAN SOCIETY FOR TESTING MATERIALS.
Mar. 28-29. Annual meeting at New York City. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Penn.

NATIONAL DRAINAGE CONGRESS.
April 10-13. Annual meeting at New Orleans, La. Vice-President, E. T. Perkins, First National Bank Bldg., Chicago.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 18-20. Annual meeting at Boston, Mass. Secy., J. W. Richards, Lehigh University, South Bethlehem, Penn.

Boston Society of Civil Engineers—At a meeting to be held at the Boston City Club Bldg., Mar. 6, F. A. Barbour will present a paper discussing the relative merits of coarse and fine screens for sewage disposal plants and C. R. Felton, City Engineer of Brockton, Mass., will tell of the results obtained with the Brockton disposal plant.

American Society of Swedish Engineers—The annual dinner was held at the society's headquarters, 271 Hicks St., Brooklyn, N. Y., Feb. 17. In celebration of the 50th anniversary of the famous fight between the "Monitor" and "Merrimac," speeches were made recalling the historical events involved and honoring the memory of Capt. John Ericsson, the inventor and designer of the victorious vessel. A resolution was passed requesting the Secretary of the Navy to take steps toward the worthy commemoration of the battle and of Capt. Ericsson.

American Society for Testing Materials—Nominations for officers to be elected at the annual meeting in New York, Mar. 28-29, have been announced as follows: For President, Robert W. Hunt; for Vice-President, A. W. Gibbs; for Secretary-Treasurer, Edgar Marburg; for membership on the executive committee, J. B. Lober, A. A. Stevenson and S. W. Stratton.

Four professional sessions will be held, two on each day of the meeting. At the morning session on Thursday, reports will be received from various committees on specifications and tests of metals; on Thursday afternoon reports will be received on standard specifications for steel, coal and coke. The Friday morning session will be devoted to reports on standard specifications for steel, wrought iron and cast iron; and the Friday afternoon session to cement, brick, sewer pipe, drain tile, lubricants, fats and oils, and waterproofing materials.

American Institute of Electrical Engineers—On the recommendation of the president, Mr. Gano Dunn, of New York City, the Directors have voted to open the columns of Part I of the monthly Proceedings, to letters on matters of current interest in the Institute affairs. This scheme was desired to afford opportunity for discussing both sides of the recent proposal to change the membership grades.

American Electric Railway Association—At the recent mid-year meeting it was decided (1) to abolish the grade of "Associate Member," (2) to grade all the present associate members as "Members," and (3) to throw all meetings open to members. Previously the meetings of the secondary associations (Engineering, Accounting, Traffic and Transportation, and Claim Agents) have been open, but most of those of the parent association have been executive and open only to official representatives of electric railways. The grade of "Associate Membership" was provided for the personal affiliation of railway and manufacturing men, electrical engineers, professors of engineering, etc.

Illinois Water Supply Association—The program of papers to be presented at the fourth annual meeting at the University of Illinois, Mar. 5 and 6, includes the following: "Does the Water Meter Increase Revenue, Reduce Consumption and Satisfy the Consumer? Experience at Elgin," R. R. Parkin; "Effect of Installing Heaters at Decatur," H. Ruthrauf; "Limitation of Stream Pollution," Paul Hansen; "Purchase of Coal in Accordance with Specifications," W. O. Collins; "Storage of Coal," F. W. Parr; "Record of Tests of New Wells made by Weir Measurement," Owen T. Smith; "Some Interesting Observations on the Disinfection of Lake Water with Calcium Hypochlorite," Arthur Lederer and Frank Bachmann, Sanitary District of Chicago; "Deep Wells at Joliet," H. A. Stevens; "Sanitary Survey of the Mississippi River at Moline," E. Bartow. In addition to the papers named, a number of papers on water supply and typhoid fever will be presented at the evening session on Mar. 5.

American Institute of Mining Engineers—At the annual business meeting of the Institute, held in New York, on Feb. 20, the committee representing the opposition to the recent proposition to amend the constitution of the society and make various radical changes in the organization, including an increase in the annual dues, had received nearly three times as many proxies from absent members as had the committee which favored the proposed changes. Instead of adopting the proposed changes in the constitution, therefore, it was voted to appoint a committee to thoroughly investigate the condition of the Institute and recommend what changes, if any, are advisable in its administration. This committee is made up as follows: Mr. C. R. Corning, of New York City, whose partner, Mr. E. E. Olcott, is a Past President of the Institute; Prof. James F. Kemp, of Columbia University; William H. Nichols, Jr., President of the San Carlos Copper Co.; George C. Stone, Chief Engineer of the New Jersey Zinc Co., and Dr. A. R. Ledoux, consulting engineer and chemist and a Past President of the society. Prof. James F. Kemp was elected President of the Institute for the ensuing year; Vice-Presidents, B. B. Thayer, Karl Eilers and W. Lindgren; Councillors, J. W. Richards, J. H., Janeway, Jr., and Sidney J. Jennings; Secretary, Joseph Struthers. For Directors of the Institute, Messrs. C. F. Rand, E. B. Kirby and George C. Stone were elected.

At the professional session in the afternoon, papers on fine-ore sintering and briquetting, electrostatic ore separation and progress in roll crushing were read and discussed. At the banquet held at the Plaza Hotel in the evening, the speakers were Geo. Otis Smith, W. L. Saunders, R. W. Raymond, H. Mortimer Lamb and Col. Hay.